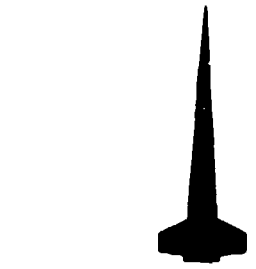


TECHNICAL REPORT-RD-WS-92-9

SERIALLY COMPLETE SEQUENCES OF HOURLY TEMPERATURES FOR THREE SAUDI ARABIAN STATIONS

Helmut P. Dudel
Dorathy A. Stewart
Larry J. Levitt
Weapons Sciences Directorate
Research, Development, and Engineering Center

JUNE 1992

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

DESTRUCTION NOTICE

FOR CLASSIFIED DOCUMENTS, FOLLOW THE PROCEDURES IN DoD 5200.22-M, INDUSTRIAL SECURITY MANUAL, SECTION II-19 OR DoD 5200.1-R, INFORMATION SECURITY PROGRAM REGULATION, CHAPTER IX. FOR UNCLASSIFIED, LIMITED DOCUMENTS, DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.

DISCLAIMER

THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS.

TRADE NAMES

USE OF TRADE NAMES OR MANUFACTURERS IN THIS REPORT DOES NOT CONSTITUTE AN OFFICIAL ENDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL HARDWARE OR SOFTWARE.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT *Approved for public release; distribution is unlimited.*
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Report RD-WS-92-9	5. MONITORING ORGANIZATION REPORT NUMBER (S)
6a. NAME OF PERFORMING ORGANIZATION Weapons Sciences Directorate RD&E Center 6b. OFFICE SYMBOL (if applicable) AMSMI-RD-WS-CM	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Commander, U. S. Army Missile Command ATTN: AMSMI-RD-WS-CM Redstone Arsenal, AL 35898-5248	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

SERIALLY COMPLETE SEQUENCES OF HOURLY TEMPERATURES FOR THREE SAUDI ARABIAN STATIONS

12. PERSONAL AUTHOR(S)

Helmut P. Dudel, Dorathy A. Stewart, and Larry J. Levitt

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM July 91 TO Mar 92	June 1992	69

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Climatology, Saudi Arabia, Temperature, Temperature Statistics, Temperature Tabulations, Temperature Time Series, Data Screening, Serially Complete Series, Riyadh, Dhahran, Qaisumah

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Serially completed sets of hourly temperatures have been produced for the three Saudi Arabian stations Riyadh, Dhahran, and Qaisumah for the ten-year period from January 1981 through December 1990. Daily maxima and minima which can occur between hourly observations have also been included. Following a brief survey of the climate of Saudi Arabia (Section II), the methods of quality control of the original data and the fill-in procedures are described (Section III). Sections IV-VI contain ten tables per station. These tables include five-day, monthly, and annual means and extremes, as well as frequency distributions of hourly temperatures. For Qaisumah, nine averaged diurnal temperature cycles are provided. After comparing the monthly temperature extremes with published data and other reference material, we conclude that the ten-year temperature series are representative of the salient features of the temperature climate of the Saudi Arabian region encompassed by the three stations.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Helmut P. Dudel	22b. TELEPHONE (Include Area Code) (205) 876-1666
	22c. OFFICE SYMBOL AMSMI-RD-WS-CM

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

ACKNOWLEDGMENTS

The authors appreciate the effort of the U.S. Air Force Environmental Technical Applications Center (USAFETAC) which provided the raw temperature data for this investigation. Two people who deserve particular thanks are Ms. H. Snelling of USAFETAC/ECE at Scott Air Force Base, IL, and Ms. J. Barger of USAFETAC/OL-A at Asheville, NC.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

I. INTRODUCTION

In the wake of Operations Desert Shield and Desert Storm, a variety of climatological investigations of the Southwest Asian environment have been performed including inputs into analyses of long-duration exposure effects on Army materiel. This report describes details of an effort to establish time series of hourly ambient temperatures for Riyadh, Dhahran and Qaisumah from a ten-year period of record. The resulting data files are, of course, too voluminous to be included here in toto, but can be obtained by interested users on data media.

This report is mainly concerned with the methods of deriving statistically and climatologically acceptable series from inhomogeneous sets of input data. As described in Section III, extensive screening of raw data was required.

The resulting serially-completed temperature time series serve as a data base for a variety of statistical evaluations that extend considerably beyond conventional monthly statistics. Results are presented here in groups of ten tables per station with corresponding arrangement of tables among the groups. For example, frequency distributions of hourly temperatures are presented in Table 1 for Riyadh, Table 11 for Dhahran, and Table 21 for Qaisumah.

The temperature time series should also be viewed against the background of long-term climatological records. To this effect, supplementary climatic information has been included in this report.

II. SAUDI ARABIAN TEMPERATURE CLIMATOLOGY BACKGROUND

A. Climate Classification

A hot desert climate prevails over a large portion of Saudi Arabia. It is characterized by (a) very high insolation throughout most of the year, (b) hot to extremely hot summer daytime temperatures, (c) very large diurnal temperature ranges, (d) relatively cold nighttime temperatures during winter with occasional freezing temperatures, (e) very low to extremely low relative humidities, (f) almost no precipitation between May and October, and (g) irregular light precipitation between November and April with annual totals of less than 100 mm.

Most climate classifications agree in including both Riyadh and Qaisumah in the hot-dry desert climate zone of the subtropics. A slight variation was given by Landsberg et al. (1965), who classified Riyadh and adjacent oases to the north and south as "Dry-Summer Steppe climate with humid winters." In another variation, Rudloff (1981) listed the climate of Riyadh as a Desert Mountain Climate.

The general climate classifications include Dhahran in the same zone as Riyadh and Qaisumah. Because of its proximity to the Persian Gulf, it experiences high absolute humidities during the warmer months. The contrast in dew point temperatures is often remarkable between Dhahran and the inland desert stations. Because of this, Dodd (1969) has suggested a separate "Humid-Hot

Coastal Desert" category for Dhahran and similar coastal locations. Dhahran has a Marine Desert climate according to Rudloff (1981).

B. Ground and Air Temperatures

The surface temperatures which were analyzed in this report are from standard weather data and should not be confused with temperatures of the ground or of exposed objects. Surface temperatures in standard meteorological data are measured in instrument shelters between 1 m and 2 m above the ground. Such shelters are supposed to be placed in open places away from the influence of buildings, but in practice this is not always done.

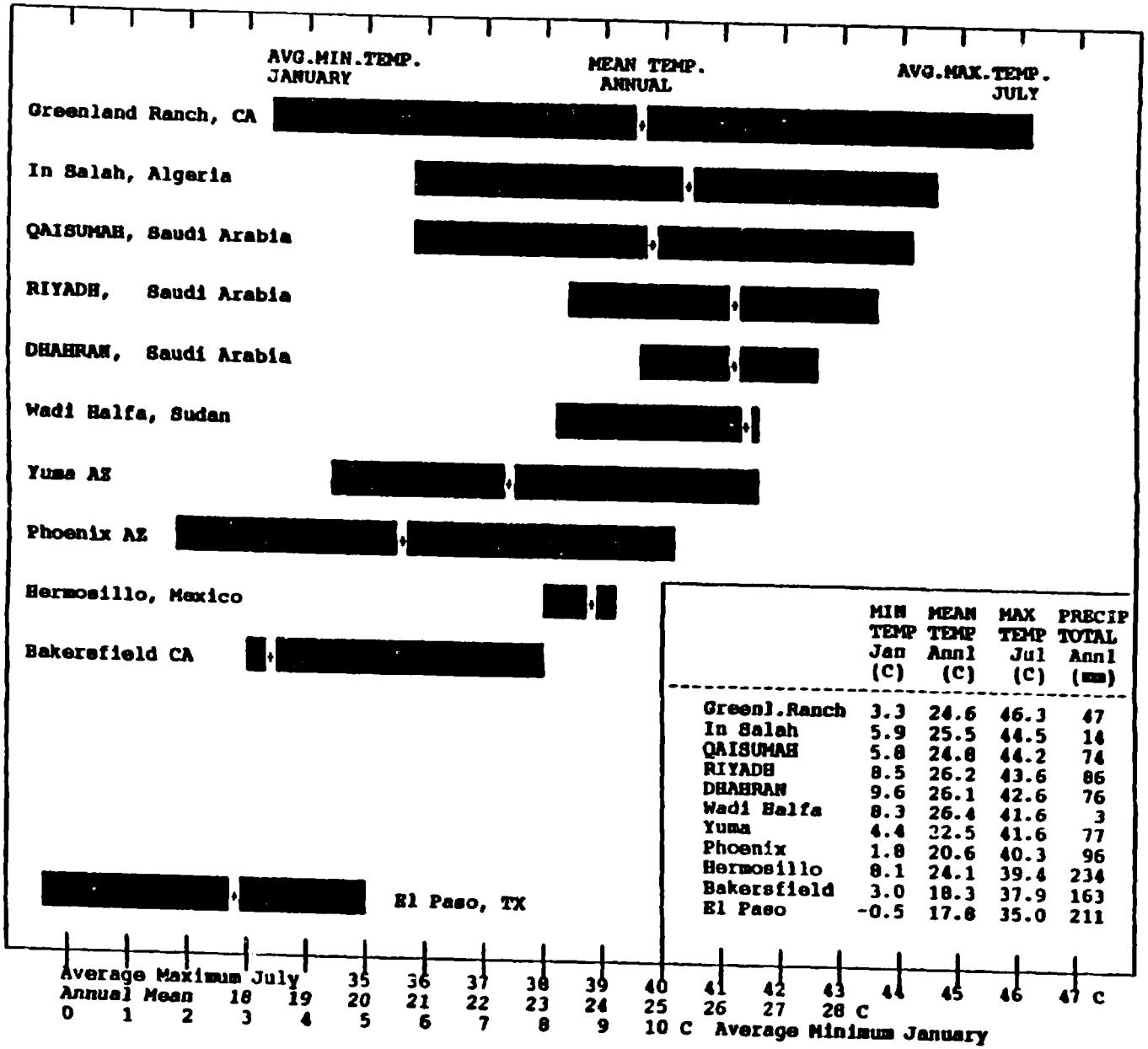
Vertical temperature gradients near the ground may be quite large, and this is especially true at midday on hot days when the ground is often 25-30 °C warmer than air in an instrument shelter. Griffiths (1966) gives an example where the temperature changed from 170 °F(76.7 °C) to 120 °C(48.9 °C) in the lowest 2 inches in the southern Arabian Peninsula. Another example of measurements of very high ground temperatures in Saudi Arabia is that by Smith (1986a) in June 1981 in the Saudi Arabian Empty Quarter. Smith's measurements revealed an average daily maximum temperature of approximately 60 °C and an average daily minimum temperature of 25 °C at a depth of 2 cm. During the very hot three days 30 May through 1 June 1981, the average daily maximum temperature was near 70 °C at the 2-cm depth.

Changes in the ground temperature can be quite rapid at daybreak. Blake et al. (1983) used a fast-response remote sensing technique to determine soil surface temperature. On 12 May 1979, the soil temperature rose from 24 °C to 48 °C within 45 minutes as the sun rose over the Empty Quarter (Rub-al-Khali Desert) in southern Saudi Arabia.

C. Comparison With Other Locations

The question may be asked whether there are other locations in the world with temperature conditions similar to those encountered in Saudi Arabia. Of special interest are comparisons with stations in the southwestern United States. While a detailed month-by-month comparison has not been undertaken here, three benchmark values of the average annual temperature cycle have been selected, namely, the average January morning low temperature, the overall mean temperature, and the average July afternoon high temperature. Figure 1 contains bar graphs of these temperatures from several potentially similar locations.

It can be seen that comparable locations - based on the three temperatures - may be found in the Saharan desert (In Salah) and possibly in Sudan (Wadi Halfa), but not in the southwestern United States. The annual mean temperature at Greenland Ranch in the Californian Death Valley is very close to that from Qaisumah, but the other two benchmarks are dissimilar. Yuma, Arizona, benchmarks are 2 °C to 4 °C lower than those from Riyadh, Dhahran or Qaisumah.



	MIN TEMP Jan (C)	MEAN TEMP Annl (C)	MAX TEMP Jul (C)	PRECIP TOTAL Annl (mm)
Greenl.Ranch	3.3	24.6	46.3	47
In Salah	5.9	25.5	44.5	14
QAISUMAH	5.8	24.8	44.2	74
RIYADH	8.5	26.2	43.6	86
DHAHRAN	9.6	26.1	42.6	76
Wadi Halfa	8.3	26.4	41.6	3
Yuma	4.4	22.5	41.6	77
Phoenix	1.8	20.6	40.3	96
Hermosillo	8.1	24.1	39.4	234
Bakersfield	3.0	18.3	37.9	163
El Paso	-0.5	17.8	35.0	211

Figure 1. Comparison of average temperatures from eleven subtropical locations: Average January daily low, annual mean, and average July daily high temperatures.

D. Other Sources on Saudi Arabian Climate

General descriptions of the overall climate of Saudi Arabia can be found in Takahashi and Arakawa (1981), Soltani (1990), and Vojtesak et al. (1991). More limited or specialized studies have been done by Pedgley (1974), Hastenrath et al. (1979), Blake et al. (1983), and Smith (1986a, b).

In addition, there exists a variety of statistical summaries of the climate of a number of Saudi Arabian locations based on various periods of record. All of them contain at least statistics on maximum and minimum temperature.

The tables published by the Meteorological Office of the Air Ministry of Great Britain (1958) are the earliest data referenced here. They include monthly and annual statistics for Riyadh (and Bahrain), but not for Dhahran or Qaisumah. Riyadh statistics were based on only three years of data from the period 1941-1945. A second edition was planned and would presumably include statistics on the latter two stations.

The U.S. Naval Weather Service (1967) World-Wide Airfield Summaries, Vol. II, Part 2, contain statistics for about 15 Saudi Arabian locations derived from different periods of record prior to 1966 and at most 10 years long. The period of record for Riyadh was 3 years, that for Dhahran was 10 years.

The U.S. Air Force Air Weather Service's Revised Uniform Summary of Surface Weather Observations (RUSSWO) and the Limited Surface Observations Climate Summary (LSOCS) contain temperature statistics in addition to lengthy climatological contingency tables. Compact summaries are available as Operational Climatic Data Summaries (OCDS) and Air Weather Service Climatic Briefs (AWS). These statistics are based on different periods of record. They are apparently revised periodically.

The International Station Meteorological Climate Summary (ISMCS, Dickenson, 1990) was jointly produced by the Naval Oceanography Command, the Air Weather Service, and the National Climatic Data Center (NCDC). It contains detailed climatological statistics from about 600 stations worldwide and mostly from the period of record from 1973 to 1989. All of this statistical information has been conveniently compiled on a single compact disc. The temperature extremes were derived from observations taken once every three hours or once every hour (if available), and therefore may not be true maximum or minimum temperatures because extremes may occur between these hours.

III. DATA SOURCE AND QUALITY CONTROL

A. Data Source and Temperature Coding Practice

Input files were provided by the U.S. Air Force Environmental Technical Applications Center (USAFETAC) which functions as part of the Air Weather Service (AWS). These files were in the form of DATSAV2 records which contain information from weather messages transmitted via teletype in two World Meteorological Organization (WMO) codes. The SYNOP (synoptic) code format is

used for observations made every 3 hours at 0000 Z, 0300 Z, 0600 Z, etc., where 0000 Z is the same as 0000 UTC (Coordinated Universal Time). Hourly aviation routine weather reports are available in the METAR code format. While there are significant differences between the two types of messages, temperature observations can be retrieved from both types, namely, reports in whole degrees Celsius from the METAR reports, and temperatures in tenths of Celsius from the SYNOP reports. In addition, the 0600 Z SYNOP report contains the minimum and the 1800 Z report the maximum temperature of the preceding 18 hours. These extremes can occur between the time of recorded hourly values. Since Saudi Arabian local standard time is three hours ahead of UTC, these extreme temperature reports should represent the actual 24-hour extremes in almost all cases.

Since the temperature data extracted from the DATSAV2 files contain many garbled or otherwise corrupted values, especially those from the METAR reports, it was necessary to devise quality control procedures for the screening of every temperature value. There are also numerous missing observations, especially in the earlier years of the record. Therefore, quality control steps had to be supplemented by a gap fill-in procedure.

B. Quality Control and Fill-In Procedure

The first step in the quality control of the data was to flag large temperature changes from one hour to the next. Differences equal to or greater than 5 °C were flagged in the screen display of ten days of 24 hourly observations per day to permit manual correction of dubious values. There were about two errors flagged in this way for every 10-day period, with the most frequently encountered type of error arising from transposed digits. Typographical errors in which the reported value differed from a reasonable value by 10 °C sometimes occurred. Frequently the flagged temperatures stemming from METAR reports appeared to have been inserted into the wrong time slot, presumably caused by a garbling in the time-of-observation. This first step is effective in salvaging many observations that otherwise would have been rejected by the following screening phases.

Another reason for this rather time-consuming manual inspection and correction phase has been to accept true temperature changes exceeding the 5 °C threshold that would have been rejected by a straightforward automatic screening procedure. The most frequently accepted large changes were rapid temperature increases in the morning hours shortly after sunrise, especially during spring and fall. Rapid temperature decreases were apparently associated with thunderstorms during the warmer part of the year and with rainshowers and/or frontal passages during the cooler season. Some hour-to-hour temperature changes much larger than 5 °C were accepted in this step.

The second step consisted of converting the temperature values into departures from the mean value for the given month and hour. These departures were then subjected to a simple harmonic analysis in which missing values were simply assumed to have a zero departure from the respective mean. The Fourier analysis of the departures from the mean was extended over ten days, that is, 240

points. Twenty harmonics were found to be an acceptable compromise in obtaining realistic results. The resulting smooth fit was used (a) to replace missing values, and (b) to replace original values if these deviated from the smooth fit by more than 4 °C, thus achieving two goals: fill-in of missing points and elimination of large spikes in the time series. To reduce the screening effort, it was deemed necessary to reduce the fit to non-overlapping 10-day periods. Note that the largest portion of the original data was accepted in this step because Fourier-derived values were only used to fill in missing or rejected values.

In the third step, the times of minimum and maximum hourly values of each 24-hour UTC day were determined. The values in these two slots were then replaced by the separately reported daily minimum and maximum temperatures. This step is an attempt to retain the true extreme temperatures for users interested in simulation for some design purposes. Unfortunately, the separately reported daily extreme values were afflicted with the same types of errors as the hourly observations. Since it was difficult or impractical to correct these pairs of data, the uncorrected values were accepted and inserted into the record, even though this step did indeed re-introduce occasional unwanted spikes.

Therefore, a fourth step was added to the screening procedure. It consists of another harmonic fit with subsequent replacement of 4 °C or more departures from it. The harmonic fit in this phase was extended over 12 days, i.e., 288 points, in an attempt to eliminate also any spikes that might have escaped detection at the boundary between the non-overlapping ten-day sequences of the earlier screening phase.

C. Brief Discussion of Output

The output has been stored on three ASCII files "TC8190.ERY," "TC8190.EDR," and "TC8190.EPA," for Riyadh, Dhahran, and Qaisumah, respectively. Each file contains 295,650 bytes. Each record contains the 24 hourly temperatures of one UTC-day, beginning with 0000 Z or 0300 LST. The record starts with a 6-character date group of the form YYMMDD (year-month-day), followed by a colon in column 7 and the 24 temperature values in tenths of a degree Celsius of 3 characters each.

As a by-product of the quality control procedure, a tally was kept of the number of missing observations that had to be filled in. The best station was Dhahran with 0.7 percent to 3.8 percent per year. Riyadh conditions were similar. The Qaisumah input file, however, was considerably worse because the METAR observations of the non-synoptic hours, that is, 0100 Z, 0200 Z, 0400 Z, etc., were frequently not made or not received. In addition, the synoptic reports from 0300 Z, 0900 Z, etc., were relatively often missing, so that the percentage of missing observations at Qaisumah ranged from 22.5 percent in 1987 to 49.1 percent in 1984.

The percentage of days on which the minimum and/or maximum temperature was missing at Dhahran ranged from 6.6 percent in 1981 to 25.5 percent in 1987, with individual months as high as 35.5 percent (July 1987). The frequency of days without minimum and/or maximum reports at Qaisumah varied between 8.1 percent in 1981 and 28.1 percent in 1990.

Statistical evaluation of the serially completed and screened temperature series will be discussed below. In the course of this evaluation, two peculiarities of the series were noted. First, there are occasional days in the record when the temperature appears to oscillate with a frequency of 2 or 3 hours and an amplitude of about 2 °C. This appears to have occurred when "ill-fitting" input values were alternately accepted and rejected by the 4 °C threshold of the fourth screening step discussed above. Secondly, frequency distributions of the screened temperatures with a class size of 1 °C show a preference for odd integers of the Celsius values. The same bias is apparent in the raw input data.

IV. STATISTICS FOR RIYADH

A. Station Location

Station Riyadh (OERY) was located at 24°42'N, 46°44'E, at an elevation of 634 m in January 1981, which is the beginning of the temperature series for this report. In March 1981 the station elevation changed to 608 m. In February 1986, the station was moved eastward to a location at 24°42'N, 46°53'E at an elevation of 611 m. Another move occurred in April 1987 when the station was moved to its present location at 24°43'N, 46°43'E at an elevation of 612 m. The WMO number of station OERY is 40438. This first-order station takes hourly observations around the clock.

Additional hourly observations as well as twice daily upper-air observations have been available since December 1983 from a second first-order station Riyadh King Khalid (OERK), WMO number 40437, with coordinates 24°56'N, 46°43'E, 612 m. Observations from this location will not be discussed here.

B. Temperature Statistics

Table 1 contains the relative frequencies of hourly temperatures by month and annually for classes of 2 degrees Celsius width. Note that during the months June through September, the frequency distributions are bimodal. The first mode corresponds to late-night hours with little change in temperature; the second mode arises from the hours before and after the time of the early afternoon maximum. In July, the first mode occurs near 32 °C, the second near 42 °C. In September, both modes shift to lower temperatures, namely 29 °C and 39 °C. This tendency toward a bimodal temperature distribution is suppressed in the colder months even though the range of temperatures is larger.

Simple interpolation was used to estimate the temperatures at the 95 and 99 percent level of non-exceedance. These values are included at the bottom of Table 1.

Table 2 contains mean hourly temperatures in tenths of degrees Celsius by month for Riyadh. Highest mean hourly temperatures occur at 1500 LST throughout the year, whereas the lowest mean hourly temperatures occur at 0600 LST except during winter when they may occur up to an hour later. The range between mean lowest and highest temperatures is larger during the

summer than during winter. The difference between the lowest and highest mean hourly temperatures is 14.2 °C during June and July. Corresponding temperature differences are 10.5 °C for December and 11.0 °C for January.

Seasonal changes of temperatures in the morning near the time of the minimum are smaller than during the warmer part of the day. The mean temperature at 0600 local time is 9.3 °C in January and 29.0 °C in July for a difference of 19.7 °C. The mean temperature at 1000 local time increases from 14.1 °C in January to 38.2 °C in July to produce an increase of 24.1 °C. The difference between the noon temperature in July and January is the difference between 41.1 °C and 17.4 °C, or 23.7 °C. The mean temperature difference between July and January is 22.9 °C at 1500 and 23.4 °C at 1800 local time. From 1800 until 0500 the difference between the mean July and January temperatures decreases monotonically.

Table 3 contains temperature statistics for 72 "five-day" periods of the year, whereby each month is partitioned into five sections of five days each plus a sixth section of variable length to complete the month. The last section is less than five days in February and is six days in thirty-one day months. All of these sections will be referred to as five-day periods in the subsequent discussion. The table contains average daily low temperatures, average daily mean temperatures, and average daily high temperatures for each five-day period. Daily means are averages of the 24 hourly values and may not agree with means from some other sources which are derived by taking half of the maximum plus the minimum. The table also includes the lowest and highest minimum temperatures recorded in each five-day period, the lowest and highest means, and the lowest and highest maxima. Also included is the standard deviation of temperature in each five-day period.

Variations of both maximum and minimum temperatures are greater in the colder part of the year than when the weather is warmer. In January, fluctuations of daily maximum temperatures are greater than fluctuations of minimum temperatures. In July, minimum temperatures show a larger variation than maximum temperatures.

At Riyadh, the coldest time of the year occurs on the average between 16 and 20 January with a mean of 13.7 °C. The hottest period is between 21 and 25 July with a mean of 37.0 °C, or in a wider sense between 1 July and 21 August. The average daily high temperature reaches at least 100 °F (37.8 °C) every day between 11 May and 5 October. During the winter, the average daily low remains below 10 °C between 16 December and 15 February.

The seasonal temperature rise in spring is usually interrupted in June. The average temperature between 16 and 25 June is lower than during the first three five-day periods. The average temperature again increases in July to reach a maximum between 21 and 25 July. The singularity in June cannot be recognized in monthly statistics. This is probably the reason that no reference to it could be found in the available literature. At this point, a definitive explanation cannot be given.

The final three columns of Table 3 contain average daily low, mean, and high temperatures which have been smoothed with a low-pass filter. A simple symmetric seven-point filter was used with the following weights: W(0)=.208333, W(1)=.19096, W(2)=.11494, and W(3)=.085744.

Table 4 contains the lowest monthly and annual temperatures in tenths of degrees Celsius. During the ten-year period, the extreme low temperature was -0.5 °C during January 1989. On the average, the annual minimum (once-a-year minimum) temperature was 2.5 °C. In every one of the ten years, there was at least one morning low of 4.3 °C or lower. On the other hand, the temperature during July was always at least 24.0 °C. During August 1988, the temperature never dropped below 28.0 °C.

Table 5 contains the average monthly and annual low temperatures by year in tenths of degrees Celsius for Riyadh. January 1989 had by far the lowest average morning low temperatures, namely 5.5 °C, compared with an average January low of 8.5 °C. On the other hand, average morning low temperatures were 28.6 °C during July and 28.2 °C during August. The month with the highest average morning lows was August 1987 with 30.1 °C.

Table 6 contains average temperatures for each month of the ten-year period. January is usually - but not always - the coldest month. January 1989 was the coldest month during this period, with 11.9 °C, compared to a ten-year January average of 14.4 °C and to the mildest January (1985) with 16.9 °C. The coldest winter season (December through February) was the winter of 1982/83 with 13.6 °C. The mildest winter periods occurred in 1986/87 and 1987/88 when the average temperatures were 16.1 °C and 16.0 °C, respectively.

The highest monthly average was the 37.9 °C in July 1987. The average temperature for July 1985 was 35.5 °C, and all other average July temperatures were between these two values. It can be seen that the variation from year to year is fairly small in July and only about half of the corresponding variation of the January averages.

Between 1981 and 1990, the hottest summer (June through August) periods were 36.6 °C in 1987 and 36.5 °C in 1988. The summer period with the lowest three-month average was during 1984 with 34.5 °C. This indicates that Riyadh summer temperatures are uniform and hot.

Table 7 shows the average daily maximum temperature by month and year. The month with the highest average daily maximum temperature was July 1987 with 45.2 °C. The average daily high of 43.6 °C for this ten-year period is not much lower which demonstrates again the uniformity of the hot summer conditions at Riyadh.

Table 8 contains the absolute maximum temperatures by month and year. The overall maximum was 48.0 °C which occurred in July 1987. It might also be mentioned that high temperatures of 100 °F (37.8 °C) or higher have occurred as early as March (in years before 1981) and as late as October. There

have been no months during the ten-year period when the afternoon temperature did not rise to at least 25.0 °C during at least one day of the month.

Table 9 contains low and high temperatures in tenths of degrees Celsius for every day in 1987 which was a very hot year at Riyadh. A string of days with a high temperature of at least 37.8 °C (100 °F) lasted from 24 April through 5 October 1987 with a single interruption on 7 May when the high was "only" 37.1 °C. During the month of July, the temperature reached or exceeded 43.0 °C on every day and never dropped below 27.0 °C. It was also during this month that the highest temperature of the ten-year period occurred, namely 48.0 °C on 25 July. Between 28 July and 13 August of that year the temperature at Riyadh did not drop below 30.0 °C.

C. Comparison With Other Sources

Extreme temperatures by month for Riyadh from some other sources are compared in Table 10. Due to natural climatic variability, different temperature extremes may be derived for different periods of record in the same location.

The earliest data referenced in Table 10 are from the Meteorological Office of the Air Ministry of Great Britain (1958). Although the period of record is listed as 1941-1945, the U.S. Naval Weather Service (1967) World-Wide Airfield Summaries, Vol. II, Part 2, contains the same information verbatim with the additional note that only 28 months from this period were actually used. The station location listed in this reference has a latitude and longitude slightly different from the locations during the later period, and the station elevation is 43 m lower than it was during the 1970s and about 20 m lower than the present location (including the 1980s).

Substantially lower minimum temperatures were reported for this early period. For example, the earlier record low was -7.2 °C, compared with a record low of -1.1 °C for the 1973-1990 period. Minimum temperatures were also much lower during other months of the earlier period.

The average lowest (once-a-month) minimum temperatures were also lower, particularly during the warm season months. For example, the average lowest minimum for July was 20.6 °C compared with 25.8 °C from Table 4 for the 1981-1990 period. The average highest (once-a-month) maximum temperatures, on the other hand, appear to have increased much less. For July, the earlier statistics show 44.4 °C, compared with a value of 45.8 °C from Table 8.

We cannot offer a definitive explanation for this change, but it may indicate that the local topography of the earlier measurement site was more favorable for the pooling of cold air during clear nights, a phenomenon which occurs at sites known as "frost hollows" in other climatic zones. Of course, if the temperature sensor were moved to higher ground, one might consider that an increase of temperature naturally occurred with height if nocturnal inversions were present. Another consideration is that substantial urbanization has taken place at Riyadh since the 1940s (Encyclopedia Americana, 1987). The population

has increased rapidly and an international airport has been constructed. This can influence both minimum and maximum temperatures.

The U.S. Army Missile Command technical report by Billions (1972) was concerned with extreme probabilities and durations of temperatures above 110 °F and 115 °F, and discussion was limited to the months April through October. For these months, the 95 and 99 percentile temperatures at the bottom of Table 1 can be compared with Billions' percentile values for the years 1958 to 1969 except for the summer of 1962 which was missing. All of the 95 percentiles for April through October were smaller during the earlier period than during 1981 through 1990. The biggest difference was for July where Billions obtained a 95 percentile of 108 °F (42.2 °C) and the present study found 44.0 °C. Nevertheless, the overall agreement is satisfactory if one considers that the present statistics include the actual daily high temperatures, whereas Billions' evaluation was restricted to three-hourly temperatures.

The Operational Climatic Data Summaries (OCDS) and Air Weather Service Climatic Briefs (AWS) contain information on temperature extremes for various periods of record for Riyadh. In comparing the average monthly extreme temperatures of an AWS evaluation of the period from 1977 to 1984 with corresponding values in Tables 4 and 8, an agreement of better than 2.0 °C was found for all months. The differences for the annual extremes are smaller than 0.7 °C. The OCDS minima were identical to the British Meteorological Office Tables and apparently do not refer to the period of record 1973-1982. Therefore, these values were not included in Table 10.

V. STATISTICS FOR DHAHRAN

A. Station Location

Station OEDR, WMO Number 40416, is located at the Dhahran airport. Prior to December 1986, the station coordinates were 26°16'N, 50°10'E, with an elevation of 21 m. Since then, the coordinates are shown as 26°16'N, 50°09'E, and its elevation as 17 m. Station OEDR is a first-order station with hourly observations around the clock. In addition, upper-air soundings are made every 12 hours.

As mentioned in subsection C, there exist statistics from earlier observations. Those from the 1960s or earlier were made at 26°17'N, 50°09'E, elevation 22 m.

Data from Dhahran represent conditions of a Humid-Hot Coastal Desert climate (Dodd, 1969). Factors affecting local conditions are (a) closeness of the desert to the west, (b) peninsular location on the Persian Gulf with its very high water temperatures during summer and fall, and (c) a regular diurnal sea-breeze circulation with light winds from the west during the night and steady winds from the north during the afternoon.

B. Comparison With Riyadh Temperatures

Tables 11-20 are arranged in the same way as Tables 1-10 for Riyadh. The following discussion will be restricted to differences between the temperature statistics at Dhahran and Riyadh.

In spite of the significant geographic differences between Dhahran and Riyadh, the mean temperatures of the two locations were almost the same, at least during the ten-year period between 1981 and 1990. The annual means differed by a mere 0.1 °C, the average Dhahran minima were higher only by 0.6 °C, and the average maxima were lower by 0.7 °C. The absolute maximum in our screened ten-year record was 48.0 °C at both locations, while the Dhahran record minimum of 1.8 °C compares with -0.5 °C in the Riyadh record. There are, however, some systematic differences in the monthly averages, because the annual temperature cycle at a coastal station tends to lag behind that at an inland station. During May, for example, Dhahran was "colder" by 1.0 °C, while during November and December it remained about 1.2 °C warmer than Riyadh.

There are also differences in the average diurnal cycle which are apparently due to the influence of the sea breeze at the Dhahran airport. During the morning hours, Dhahran remains consistently warmer than Riyadh throughout all months. The daily maximum at Dhahran is reached around 1400 LST during winter and 1300 LST during summer, which is earlier than at Riyadh. Dhahran temperatures then remain lower than those at Riyadh throughout the afternoon. Between February and October this difference extends well into the night. The time of the early morning minimum at Dhahran varies between 0500 LST during summer and about 0615 LST during winter.

The diurnal cycles for January and July from both stations are shown in Figure 2. The curves represent a 4-term harmonic fit of the 24 hourly values.

Although humidity conditions are not otherwise discussed in this report, it should be mentioned that Dhahran sometimes experiences dew point temperatures which are among the highest recorded anywhere in the world. However, *average* Dhahran dew point temperatures are not excessive, and the annual average is approximately 9 °F lower than at the Bahrain airport, located only 45 km to the east but on an island. The highest average monthly dew point at Dhahran occurs in September. During this month, Dhahran has an average dew point temperature of 66 °F compared with 77 °F at Bahrain, 75 °F at Jiddah, or 78 °F at Gizan. The latter two Saudi stations are located on the Red Sea.

C. Comparison With Other Sources

There are more statistics from earlier periods available for Dhahran than for Riyadh or Qaisumah. Regular records apparently exist from at least 1946 onward. Extreme temperatures found in four of these evaluations are compared with current statistics in Table 20.

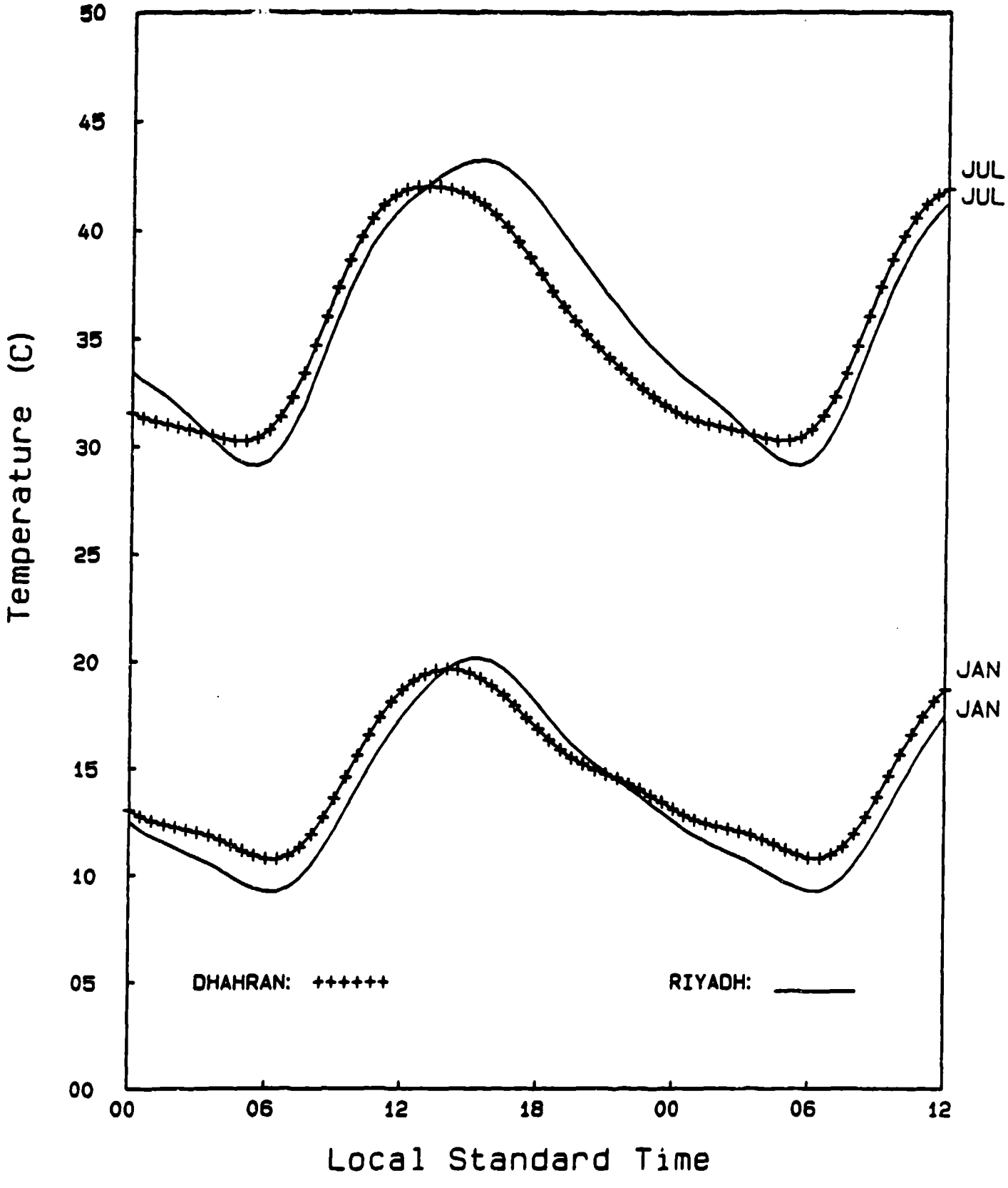


Figure 2. Riyadh and Dhahran average diurnal temperature cycle for January and July.

The combined extremes from the period 1946 to 1989 are naturally more extreme than those from the ten-year period 1981-1990. For example, the earlier data for January and February contain minima that are lower by 2 °C, including a -0.5 °C record low that seems to have occurred between 1963 and 1972. The earlier records for January and February also show daytime maxima of 35.6 °C (96 °F), while our ten-year record contains only 28.0 °C as maximum for January and 29.8 °C for February.

The most conspicuous earlier extreme value is a record maximum of 51.1 °C (124 °F), the highest among all available statistics from the three stations. It is listed as an August extreme and was apparently recorded between 1962 and 1973. The highest maximum reported since 1973 has been 48.9 °C (120 °F).

In addition to extremes, averages of the daily high and low temperatures have been compared. Figure 3 shows average daily lows and highs for January, July, and the year for four periods of record starting with 1955-1964, assumed to be the period of record of the World-Wide Airfield Summaries (U.S, Naval Weather Service, 1967). There is substantial overlap between the four periods of record. Therefore, caution is advised in interpreting any possible trend in the averages. Since earlier statistics are available only in whole degrees Fahrenheit, all data in Figure 3 are given in degrees Fahrenheit.

The annual average of the daily highs during the 1981-1990 period has remained essentially unchanged compared with earlier periods. For example, the World-Wide Airfield Summaries show an annual average of the daily high temperatures of 32.2 °C (90 °F) which coincides exactly with the corresponding value for the 1981-1990 period. The more recent average afternoon highs seem to be slightly lower during January, but slightly higher during July.

The average daily low temperatures of the 1981-1990 period are lower than during earlier periods, especially during the winter months. For example, recent January and February averages are 2.0 °C or 2.6 °C lower during the 1955-1964 period. This is in contrast to the possible trend discussed in the section on Riyadh.

VI. STATISTICS FOR QAISUMAH

A. Station Location

Station OEPA is located at the airport of Qaisumah (Al Qaisumah or Quaisumah), approximately 400 km to the north of Riyadh. Its WMO station number is 40373. In some catalogues, the station is called Hafar al Batin, which is a town 20 km to the northwest of the airport. Throughout the period 1981-1990, the station coordinates have remained the same at 28°20'N, 46°07'E. Slightly different values have been reported for the elevation of the observation site, namely 356 m or 359 m between January 1981 and June 1985, 360 m from June 1985 until May 1988, and 355 m from May 1988 to the present. Station OEPA is a first-order

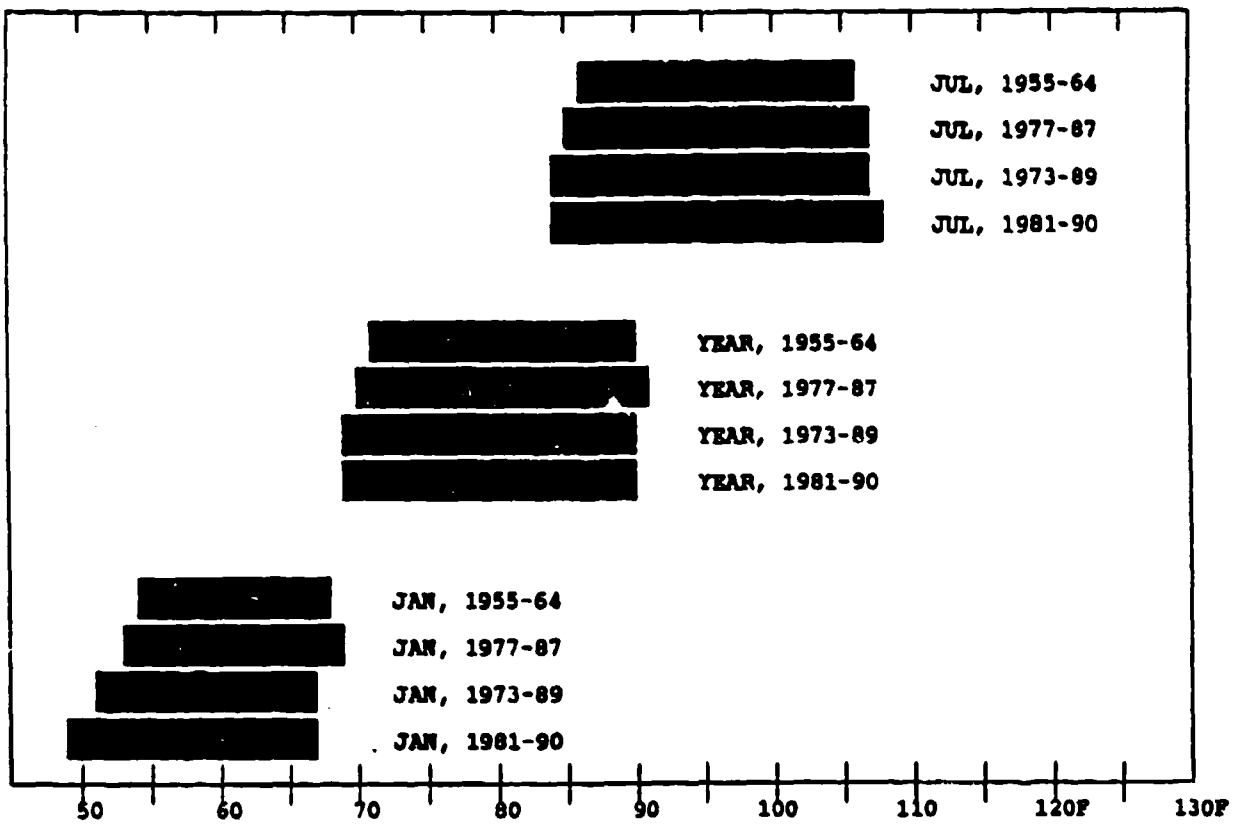


Figure 3. Comparison of Dhahran average daily low and high temperatures from different periods of record.

meteorological site that takes hourly surface observations and twice-daily upper-air observations. According to a 1991 National Geographic map of Saudi Arabia, King Khalid Military City is located about 60 km to the southwest of Qaisumah.

B. Comparison With Riyadh and Dhahran

Tables 21-30 contain temperature statistics for Qaisumah. As might be expected from its more northerly location, Qaisumah experiences lower temperatures than Riyadh during the cooler months. Average minimum temperatures were lower by approximately 2.7 °C between November and March, while corresponding average maxima were also lower by about 2.5 °C. Compared with Dhahran, average cool season (November to March) minima at Qaisumah were lower by 4.0 °C, corresponding average maxima by 2.0 °C. The difference of the averages of the annual minimum, i.e. the once-a-year minimum, is also instructive. While the Qaisumah average was -0.3 °C, Riyadh had 2.5 °C and Dhahran 4.4 °C. The lowest temperature during the ten-year period at any of the three stations was the -2.8 °C recorded at Qaisumah during January 1989.

During summer, differences between the three stations are smaller. Average morning minima at Qaisumah are lower than those at Riyadh and Dhahran by about 1 °C. On the other hand, average afternoon maxima at Qaisumah are 0.5 °C and 1.6 °C higher than those at Riyadh and Dhahran, respectively. Once-a-year maxima were also higher by about 1.3 °C.

The relative frequency distributions of temperature for Qaisumah in Table 21 are similar to the ones for Riyadh in Table 1. This similarity includes distinct bimodality of the distributions for the months of June through September.

Interruption of the seasonal temperature increases in June can also be found at Qaisumah (see column Daily Mean/Average in Table 23). The average of the daily mean temperature decreases 1.0 °C from the first to the fourth five-day period in June. Thereafter, five-day mean temperatures increase again until highest mean temperatures of the year are reached during the period between 21 and 25 July, with 37.4 °C which is slightly higher than the corresponding value of 37.0 °C for Riyadh.

C. Comparison With Other Sources

Few temperature statistics are available for Qaisumah from earlier periods of record.

The 95 and 99 percentiles at the bottom of Table 21 can be compared to those found by Billions (1972) for April through October. Billions used the record for these months from 1963 through 1969. For July, both 95 and 99 percentiles were 2 °C higher in the Billions report, but the 95 percentile for August was 4 °C lower in the Billions report. Other 95 and 99 percentiles from April through October were similar in the two investigations. As mentioned earlier, differences are probably not only due to the different periods of record but also to the differences in the composition of the data inputs, since Billions' statistics were derived from three-hourly observations only.

In Table 30 Qaisumah extreme temperatures given in the Billions (1972) report and in the International Station Meteorological Climate Summary (Dickenson, 1990) are compared with extremes in this report. There is good agreement concerning the extreme maximum temperatures in the three statistics. There is also good agreement in most months between the extreme minimum temperatures from the ISMCS, based on the 1973-1989 period, and the present evaluation based on the 1981-1990 period. Exceptions are the lower ISMCS minima for July, August, and September. These three values were rejected by our screening procedures. Inspection of the hourly temperatures from the DATSAV2 files revealed discrepancies with the separately reported minimum for each of the three dates in question. These values are indicated by an asterisk in Table 30.

D. Selected Temperature Cycles for Qaisumah

Among the three stations, Qaisumah shows the most extreme temperatures climate. It has the lowest temperatures in winter and the highest

temperatures in summer. It is therefore suggested for those applications that are limited to the evaluation of a single station file.

If the ten-year series of hourly temperature data (87,648 data points) is too large as input for certain applications, various shortcuts can be suggested that attempt to retain some of the statistical characteristics of the full data set.

One can restrict the temperature input to a single year, i.e. 8,760 data points. The selection of a representative year or 12-month period is, however, rather arbitrary. At Qaisumah, the year 1988 had 11 months with small departures from the respective mean, and may therefore be considered as an average year. On the other hand, the year 1987 was the hottest year during the period of record at all three stations.

If only hot summer conditions are required, the conditions during the summer of 1987 are probably suitable. As mentioned elsewhere, above-average temperatures prevailed during that summer. At Qaisumah, the 92-day period with the highest mea mperature (36.4 °C) began on 23 May 1987, whereas the hottest 30-day period an on 18 July 1987. During this 30-day period, the average temperature was 39.0 , and the average daily maximum 47.0 °C.

For the users who require even more compact input data, a set of just nine representative diurnal temperature cycles Q1 through Q9 is presented in Table 31 and depicted in Figure 4. They were generated by averaging the hourly temperatures at Qaisumah on days with a high temperature falling into one of nine 5-degree ranges, with <12.5 °C for Q1, 12.5 °C to 17.4 °C for Q2, 17.5 °C to 22.4 °C for Q3, etc. The nine sets were sufficient to cover the annual range. Table 31 also contains the frequency with which each cycle occurred. For example cycle Q1 (cold winter days) occurred 1.5 percent of the time, cycle Q9 (hot summer days) occurred 0.5 percent of the time, and Q7 occurred 23.9 percent of the time.

For users interested in summer conditions only, diurnal cycles Q10 through Q13 were compiled and are listed in Table 31. These four cycles are sufficient to cover the range of summer conditions. Cycle Q13 is identical with cycle Q9 since both were derived entirely from summer days.

For comparison, the last column of Table 31 contains the 24 hourly design temperatures for Hot-Dry conditions according to both AR 70-38 (1979) and MIL-STD-810E (1989). The highest hourly design temperature is 49.0 °C as compared with 47.5 °C for cycle Q13. These design temperatures are higher than cycle Q13 throughout the afternoon and evening hours but agree reasonably well with Q13 during the remainder of the 24-hour period.

The 13 diurnal cycles have been approximated by a four-term harmonic fit of the form $E(T) = TMEAN + A1*\cos(PHI) + B1*\sin(PHI) + A2*\cos(2*PHI) + B2*\sin(2*PHI) + \ldots$, where $PHI=2*\pi*t/24$ and t is in hours of Local Standard Time. Numerical values for TMEAN and the coefficients A1 through B4 are included in Table 32.

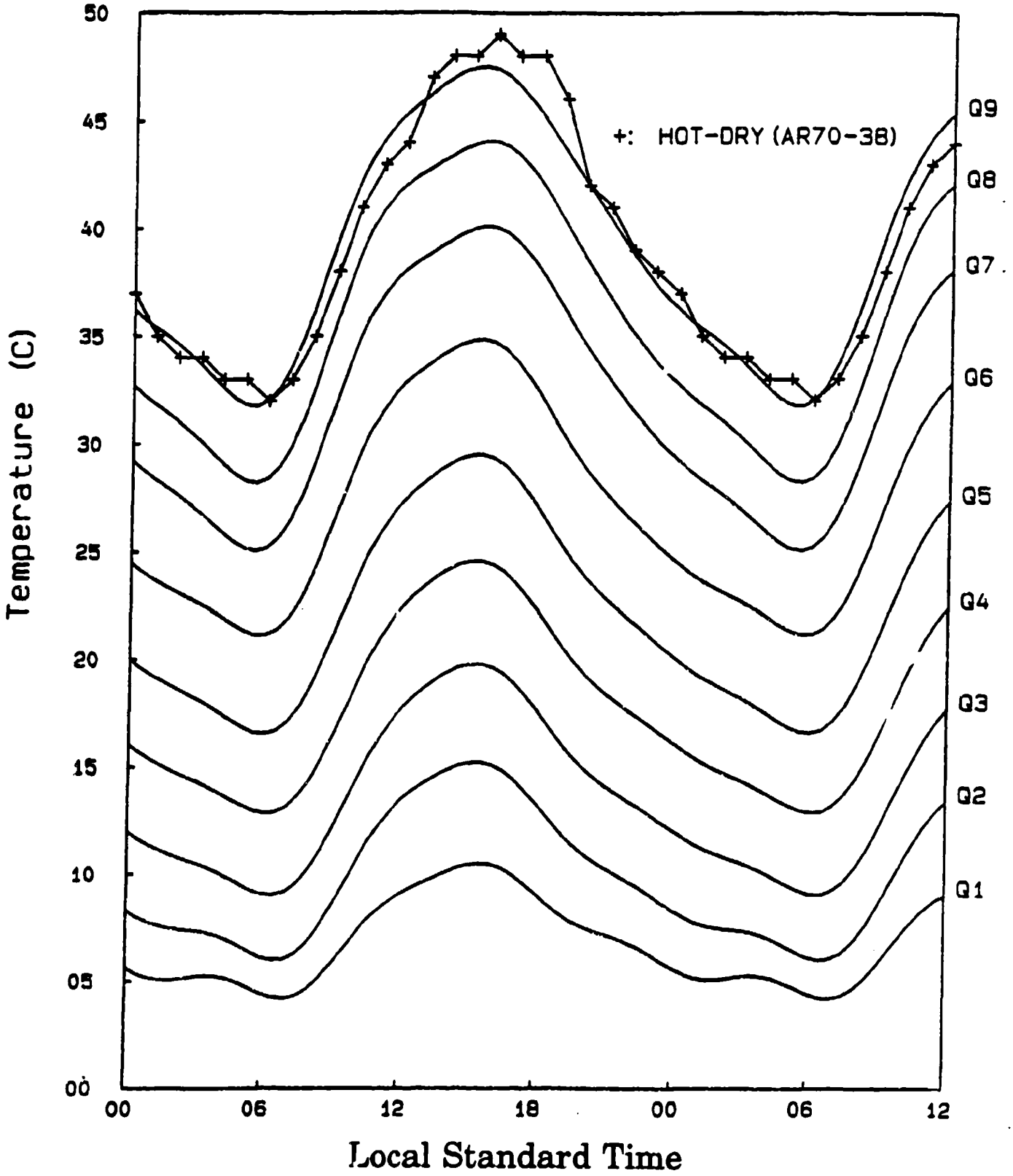


Figure 4. Qaisumah mean diurnal temperature cycles Q1 – Q9 and hot–dry temperature cycle from AR 70–38.

VII. SUMMARY AND CONCLUSIONS

Serially complete sets of hourly temperature data were established for Riyadh, Dhahran, and Qaisumah (Hafar al Batin) for the ten-year period from 1981 to 1990. Since the inputs contained many gaps and errors, the data were processed through a specially devised quality control procedure that replaced missing values and large outliers. Lowest and highest hourly values of every day were replaced by the reported minima and maxima.

Monthly means and extremes derived from these three temperature time series have been summarized in Table 33. Naturally, these statistics may differ somewhat from evaluations that did not replace missing observations or correct unreasonable raw data.

Riyadh, Dhahran, and Qaisumah are very hot from May through September. During July, normally the hottest month, average daytime maxima were near 43 °C, average monthly (once-a-month) maxima near 46 °C, and ten-year extremes 48 °C or 50 °C (Qaisumah). Average July morning minima were near 28 °C. At all three stations, July temperatures always remained above 23 °C. Differences between the three stations were small.

January was usually the coldest month at all three stations with average morning minima ranging from 9.6 °C at Dhahran to 8.5 °C at Riyadh and 5.8 °C at Qaisumah. Corresponding average monthly (once-a-month) minima were 4.8 °C, 3.5 °C, and 0.9 °C. Absolute minima during the ten-year period were 1.8 °C at Dhahran, -0.5 °C at Riyadh, and -2.8 °C at Qaisumah. The average daily maximum for January was 17.5 °C at Qaisumah and approximately 3 °C higher at the other two stations.

The range between average daily minimum and maximum temperatures was larger at Riyadh and Qaisumah than at Dhahran and larger during summer than during winter. Average values for January were 10.4 °C at Dhahran, 11.7 °C at Qaisumah, and 12.1 °C at Riyadh. During July, the average diurnal ranges were 13.9 °C, 16.6 °C, and 15.0 °C, respectively.

Seasonal changes of average daily minimum temperature are smaller than seasonal changes of average daily maximum temperatures. This is particularly true at Qaisumah where the average daily minima are 27.6 °C and 5.8 °C for July and January, respectively, and the average daily maxima for these two months are 44.2 °C and 17.5 °C.

At Riyadh and Qaisumah, the maximum of the diurnal temperature cycle occurred on the average around 1500 LST in winter and 1600 LST during summer. At Dhahran, it occurred earlier, namely around 1400 LST in winter and already during 1300 LST during summer, probably because of a distinct sea breeze.

The average annual cycle of temperature shows the usual sine wave shape, but inspection of average temperatures at five-day intervals reveals an anomaly during the second half of June. In the average, the steady seasonal temperature rise is temporarily slowed down. At Qaisumah and Riyadh, the mean

temperatures during the fourth and fifth five-day periods in June are even slightly lower than the mean temperature during the first half of June. The temperature then increases during the last few days of June until near the end of July. At Dhahran, this pattern is followed by the maximum temperature but not by the minimum temperature. While it is reasonable to assume that this singularity is connected to the regular seasonal changes in the large-scale Southwest Asian circulation, the intervening meteorological factors remain to be investigated.

Monthly temperature records from some available technical publications and reference material were compared with those values derived from the ten-year time series of temperatures discussed in this report. Temperature statistics from earlier periods show the following more extreme minima and maxima: At Riyadh, a record low of -7.2 °C was reported from a pre-1946 location different from the present site; at Dhahran, a record high of 51.1 °C (124 °F) was recorded in the 1960s. Other than that, the 1981-1990 extreme temperatures are comparable to those found in earlier investigations. The present averages also compare well with earlier averages, except possibly at Dhahran where more recent average morning minima appear to be 1-2 °C cooler than earlier average minima. It may be assumed that our serially-complete hourly temperature series are representative of the Saudi Arabian region encompassed by Rivadh, Dhahran, and Qaisumah.

TABLE 1. Riyadh (OERY), Jan 1981 – Dec 1990: (a) Relative Frequencies of Hourly Temperatures (percent), (b) 95% and 99% Temperatures (Celsius), by Month

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temp. Class													
-4..-3C:	.	.	.	.	.	.	.	.	.	.	.	.	.
-2..-1C:	0.01	.	.	.	.	.	.	.	.	.	.	.	0.00
0..+1C:	0.11	0.08	.	.	.	.	.	.	.	.	.	0.01	0.02
2..+3C:	0.59	0.10	.	.	.	.	.	.	.	.	.	0.14	0.07
4..+5C:	1.68	0.79	0.04	.	.	.	.	.	.	.	.	1.09	0.30
6..+7C:	4.87	2.38	0.20	.	.	.	.	.	.	.	0.06	3.78	0.94
8..+9C:	9.97	6.40	0.74	.	.	.	.	.	.	.	0.56	6.83	2.03
10..11C:	13.59	9.93	2.66	0.01	.	.	.	.	.	.	1.79	10.24	3.16
12..13C:	15.65	12.75	5.22	0.25	.	.	.	.	.	0.07	3.25	14.46	4.27
14..15C:	15.03	14.18	8.28	1.24	.	.	.	.	.	0.51	7.71	14.80	5.10
16..17C:	13.29	13.53	12.02	3.28	.	.	.	.	0.03	2.31	11.90	14.42	5.86
18..19C:	9.77	12.62	14.18	6.63	0.24	.	.	.	0.14	4.48	13.53	10.86	5.99
20..21C:	5.94	10.43	13.95	10.06	0.67	0.01	.	.	0.58	7.53	13.71	8.75	5.93
22..23C:	4.07	7.50	11.51	12.63	2.33	0.24	.	0.07	2.10	10.38	13.01	6.08	5.80
24..25C:	3.01	4.45	10.26	13.74	5.96	1.38	0.27	0.74	5.82	12.69	10.92	4.61	6.15
26..27C:	1.75	3.07	7.77	13.07	9.85	6.11	1.67	3.63	9.04	11.75	10.29	2.94	6.74
28..29C:	0.50	1.13	5.74	11.83	12.12	11.31	6.94	8.27	12.15	11.84	7.24	0.95	7.52
30..31C:	0.18	0.54	3.95	10.11	12.69	11.72	11.94	11.56	11.57	11.49	4.22	0.04	7.54
32..33C:	.	0.13	2.27	7.96	12.88	11.26	11.96	12.42	11.01	9.69	1.68	.	6.81
34..35C:	.	.	1.13	5.03	12.15	11.35	11.21	11.34	10.78	8.62	0.14	.	6.02
36..37C:	.	.	0.09	2.71	11.72	11.38	10.66	10.70	12.15	6.55	.	.	5.53
38..39C:	.	.	.	1.32	10.04	12.93	10.34	12.64	12.61	1.91	.	.	5.17
40..41C:	.	.	.	0.15	7.35	13.81	14.09	14.03	8.88	0.20	.	.	4.91
42..43C:	.	.	.	.	1.83	7.03	14.49	11.29	2.94	.	.	.	3.16
44..45C:	.	.	.	.	0.18	1.35	5.82	3.04	0.19	.	.	.	0.89
46..47C:	.	.	.	.	.	0.14	0.61	0.28	.	.	.	.	0.09
48..49C:	.	.	.	.	.	.	0.03	.	.	.	.	.	0.00
49..50C:	.	.	.	.	.	.	.	.	.	.	.	.	.
T95 :	23.8	25.4	30.7	35.2	40.7	42.5	44.0	43.2	41.1	36.6	30.0	25.0	41.2C
T99 :	27.1	28.9	33.9	38.2	42.6	44.2	45.4	45.0	43.0	38.7	32.5	27.5	43.5C

TABLE 2. Riyadh (OERY), Jan 1981 – Dec 1990: Average Hourly Temperatures by Month (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LST												
0000	125	144	189	237	300	319	336	329	300	249	190	136
0100	119	137	182	230	291	309	326	319	290	239	182	130
0200	113	130	176	223	283	300	317	311	282	231	175	124
0300	107	123	170	216	274	291	308	304	275	226	171	121
0400	101	118	163	210	266	284	300	297	267	219	165	116
0500	98	113	159	205	261	276	294	290	261	213	160	111
0600	93	109	155	201	257	273	290	285	255	207	156	108
0700	93	108	158	209	271	290	306	296	266	214	159	108
0800	104	122	172	228	293	318	333	322	291	238	176	120
0900	122	142	191	249	315	342	360	351	322	268	201	141
1000	141	162	208	267	335	363	382	373	348	293	222	160
1100	159	179	225	284	351	379	400	390	367	313	240	177
1200	174	194	239	297	365	392	411	402	380	325	253	190
1300	186	205	250	307	375	402	421	412	390	335	264	201
1400	195	214	258	315	383	410	429	420	397	341	272	208
1500	203	221	265	320	387	415	432	423	399	344	275	213
1600	199	219	263	317	383	412	429	421	395	338	270	209
1700	190	212	257	310	377	406	423	414	386	329	259	200
1800	179	202	247	300	367	396	413	403	374	314	247	187
1900	167	189	235	287	355	382	399	389	358	299	235	175
2000	156	179	224	276	341	366	382	373	343	287	225	165
2100	148	169	214	265	329	352	368	361	331	277	215	158
2200	140	160	205	256	318	340	356	350	321	267	206	150
2300	132	151	196	246	309	329	345	340	309	258	197	144

TABLE 3. Riyadh (OERY), Jan 1981 – Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10)

	Daily Low				Daily Mean				Daily High				Smoothed Avg.		
	Min	Avg	Max	SD	Min	Avg	Max	SD	Min	Avg	Max	SD	Low	Mean	High
"Five-Day": Period :															
JAN 01--05:	30	83	147	27	68	141	209	27	120	204	284	35	85	142	204
JAN 06--10:	-5	83	140	28	59	143	202	29	120	209	274	40	83	141	204
JAN 11--15:	10	81	150	28	84	141	210	32	102	201	300	45	83	141	203
JAN 16--20:	10	80	150	33	79	137	203	34	130	199	298	41	85	143	204
JAN 21--25:	22	89	170	36	83	149	228	35	134	215	310	44	88	145	206
JAN 26--31:	20	96	170	30	86	149	236	33	101	207	305	45	90	148	209
FEB 01--05:	36	95	180	30	89	153	236	33	112	213	290	44	93	151	212
FEB 06--10:	0	97	164	37	86	155	230	39	115	217	300	46	96	155	217
FEB 11--15:	23	88	150	24	103	154	202	26	140	218	282	35	99	160	221
FEB 16--20:	60	110	180	26	121	172	250	28	170	235	320	35	103	165	227
FEB 21--25:	42	107	170	29	96	170	231	29	152	234	320	37	110	172	234
FEB 26--28:	50	113	200	32	113	175	261	38	144	236	330	46	117	179	241
MAR 01--05:	49	125	181	36	108	187	249	36	168	249	340	46	126	188	250
MAR 06--10:	82	142	200	35	122	207	283	43	130	271	352	50	134	196	258
MAR 11--15:	82	144	200	28	130	205	277	35	168	266	354	45	141	203	265
MAR 16--20:	88	147	212	30	143	212	291	36	180	276	370	45	148	210	272
MAR 21--25:	90	161	230	33	118	225	287	35	140	289	354	42	155	217	279
MAR 26--31:	90	155	218	29	146	213	287	34	170	271	366	44	162	224	285
APR 01--05:	110	168	230	28	159	231	288	32	200	294	370	40	170	233	295
APR 06--10:	122	179	238	29	200	243	311	26	250	305	392	32	180	244	306
APR 11--15:	152	198	250	22	215	262	325	25	248	325	406	32	189	253	317
APR 16--20:	148	204	250	24	173	272	322	28	220	340	400	33	200	266	331
APR 21--25:	144	209	270	30	198	276	326	30	250	344	400	35	209	275	341
APR 26--30:	162	211	258	25	231	279	335	25	284	345	408	30	218	285	352
MAY 01--05:	190	238	290	25	260	309	350	22	315	377	420	25	227	295	362
MAY 06--10:	184	239	280	22	239	305	340	23	290	371	420	28	236	305	372
MAY 11--15:	180	242	290	26	245	311	356	23	316	379	420	23	244	315	381
MAY 16--20:	207	257	310	22	295	331	359	15	350	398	430	18	253	325	391
MAY 21--25:	220	263	300	18	308	340	365	12	355	408	450	19	259	332	400
MAY 26--31:	238	271	310	16	310	345	379	13	370	413	450	17	264	339	407
JUN 01--05:	220	272	305	20	309	349	378	16	380	418	460	17	267	343	412
JUN 06--10:	230	276	320	20	333	354	380	14	390	425	451	13	268	344	414
JUN 11--15:	220	271	330	22	322	350	390	16	382	421	462	20	267	345	415
JUN 16--20:	210	263	309	20	315	343	381	13	390	415	460	15	267	345	415
JUN 21--25:	230	263	286	13	318	340	359	9	386	412	430	11	267	346	417
JUN 26--30:	224	269	298	16	326	351	378	12	380	422	450	16	270	349	420
JUL 01--05:	240	279	326	19	332	358	386	11	400	431	452	13	274	352	424
JUL 06--10:	256	281	300	13	334	362	379	9	400	432	460	13	278	357	428
JUL 11--15:	246	289	330	17	338	364	398	12	400	435	460	13	282	360	431
JUL 16--20:	250	285	320	16	343	366	381	9	411	438	460	12	285	362	433
JUL 21--25:	260	294	322	13	352	370	389	10	410	440	480	14	286	363	433
JUL 26--31:	240	290	352	23	347	369	415	15	410	439	475	17	287	362	432

TABLE 3. Riyadh (OERY), Jan 1981 – Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10) (cont'd)

	Daily Low				Daily Mean				Daily High				Smoothed Avg.		
	Min	Avg	Max	SD	Min	Avg	Max	SD	Min	Avg	Max	SD	Low	Mean	High
"Five-Day": Period :															
AUG 01--05:	250	289	338	21	331	362	391	15	398	431	465	16	285	361	430
AUG 06--10:	248	286	324	18	336	362	394	14	385	432	468	16	284	359	428
AUG 11--15:	238	285	335	20	331	357	394	14	401	426	462	13	282	356	426
AUG 16--20:	229	282	330	24	318	358	392	16	384	429	468	16	279	353	424
AUG 21--25:	228	281	320	22	328	358	383	15	398	432	450	14	276	351	422
AUG 26--31:	227	273	320	20	329	348	380	14	392	420	458	15	272	347	418
SEP 01--05:	228	271	315	18	326	345	380	11	380	415	440	12	268	343	415
SEP 06--10:	240	270	293	14	320	347	362	9	390	421	440	11	262	337	410
SEP 11--15:	225	258	296	20	307	333	360	16	382	407	440	16	255	330	403
SEP 16--20:	220	250	290	20	278	326	352	14	350	400	430	15	247	323	397
SEP 21--25:	161	237	280	23	265	315	351	18	349	391	420	17	239	316	390
SEP 26--30:	189	229	270	21	282	311	335	13	360	387	410	12	231	307	381
OCT 01--05:	193	229	280	20	281	306	340	14	350	380	410	14	224	299	373
OCT 06--10:	170	220	270	22	245	295	319	18	310	370	393	18	216	289	362
OCT 11--15:	150	211	258	29	203	281	318	29	240	352	392	34	207	279	351
OCT 16--20:	150	200	244	23	189	271	303	22	243	342	388	24	198	269	339
OCT 21--25:	130	188	240	28	185	257	300	25	254	328	364	23	189	258	327
OCT 26--31:	134	180	227	23	212	251	290	17	277	319	364	21	180	247	314
NOV 01--05:	138	176	220	20	191	234	279	18	230	302	348	26	171	236	303
NOV 06--10:	126	170	210	23	177	234	265	18	220	301	334	24	161	225	292
NOV 11--15:	70	149	210	33	124	211	263	37	184	275	330	44	152	216	281
NOV 16--20:	80	137	176	26	135	202	244	24	196	271	330	29	143	205	270
NOV 21--25:	76	131	190	24	140	197	236	24	200	265	310	30	134	196	260
NOV 26--30:	90	139	180	19	107	198	245	26	128	258	312	36	126	186	249
DEC 01--05:	38	123	175	31	55	179	227	40	80	237	296	55	118	176	238
DEC 06--10:	32	97	148	29	82	154	208	36	120	217	290	49	110	167	229
DEC 11--15:	40	102	160	25	90	162	209	27	140	225	300	37	102	159	221
DEC 16--20:	50	96	148	28	89	152	205	34	110	214	294	47	96	153	214
DEC 21--25:	33	96	150	29	107	153	206	26	140	213	270	35	91	148	210
DEC 26--31:	10	85	158	32	84	142	203	32	130	203	280	41	88	145	207

TABLE 4. Riyadh (OERY), Jan 1981 – Dec 1990: Lowest Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Min.
Year													
1981:	30	50	80	130	190	250	250	240	200	170	90	80	30
1982:	22	30	90	130	180	250	253	255	240	170	80	40	22
1983:	42	36	52	136	207	255	265	246	220	155	128	42	36
1984:	48	43	49	174	203	236	270	246	230	130	134	60	43
1985:	68	30	50	149	198	245	264	268	195	148	130	40	30
1986:	22	50	110	140	184	239	252	269	230	154	100	32	22
1987:	40	70	90	130	240	250	270	233	250	178	120	58	40
1988:	44	70	115	147	223	224	266	280	221	185	70	20	20
1989:	-5	0	90	110	203	210	240	227	161	142	124	33	-5
1990:	36	50	74	150	180	220	246	229	204	170	76	10	10
Min:	-5	0	49	110	180	210	240	227	161	130	70	10	-5
Avg:	35	43	80	140	201	238	258	249	215	160	105	42	25
Max:	68	70	115	174	240	255	270	280	250	185	134	80	43

TABLE 5. Riyadh (OERY), Jan 1981 – Dec 1990: Average Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	110	112	152	200	245	270	286	279	247	204	148	113	197
1982:	90	85	139	196	250	277	286	277	270	219	131	78	192
1983:	76	88	118	188	261	288	292	291	249	180	151	96	190
1984:	77	110	159	216	246	262	288	263	254	192	164	104	195
1985:	115	89	146	189	249	267	281	290	250	199	167	93	195
1986:	76	98	146	174	248	262	286	293	254	215	147	88	191
1987:	84	122	146	199	278	274	296	301	272	234	151	117	206
1988:	87	116	160	202	257	283	300	300	264	216	145	106	203
1989:	55	80	146	183	241	251	272	265	228	183	172	96	181
1990:	84	107	147	198	245	255	275	264	238	196	127	96	186
Min:	55	80	118	174	241	251	272	263	228	180	127	78	181
Avg:	85	101	146	195	252	269	286	282	253	204	150	99	194
Max:	115	122	160	216	278	288	300	301	272	234	172	117	206

TABLE 6. Riyadh (OERY), Jan 1981 – Dec 1990: Mean Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	164	175	219	274	318	350	365	357	326	274	213	181	268
1982:	151	137	192	258	318	352	360	348	343	276	176	127	253
1983:	129	153	181	250	325	355	364	359	325	256	222	158	256
1984:	145	175	226	278	315	336	361	337	325	262	216	152	261
1985:	169	155	210	259	319	345	355	365	328	276	228	149	263
1986:	137	165	210	244	324	344	365	367	329	288	208	140	260
1987:	152	195	202	273	342	349	379	369	343	293	219	171	274
1988:	141	169	223	261	330	356	371	367	335	289	210	166	268
1989:	119	143	209	244	324	342	367	354	317	266	229	150	255
1990:	130	159	212	268	330	349	363	351	325	281	211	172	263
Min:	119	137	181	244	315	336	355	337	317	256	176	127	253
Avg:	144	163	208	261	325	348	365	357	330	276	213	157	262
Max:	169	195	226	278	342	356	379	369	343	293	229	181	274

TABLE 7. Riyadh (OERY), Jan 1981 – Dec 1990: Average Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	224	240	281	343	387	422	436	425	398	343	281	252	336
1982:	214	191	252	321	383	422	429	418	416	338	228	176	316
1983:	185	216	240	312	384	417	433	422	401	332	295	220	321
1984:	211	244	290	345	381	409	431	409	397	337	273	202	327
1985:	233	225	277	326	385	417	425	435	403	354	296	214	333
1986:	211	231	276	311	394	416	441	440	404	360	269	196	329
1987:	221	261	258	340	403	418	452	436	413	355	289	227	339
1988:	195	222	284	320	402	425	436	434	409	360	278	237	334
1989:	184	203	272	307	396	414	441	432	393	342	290	206	323
1990:	181	218	275	334	403	427	437	428	402	355	289	246	333
Min:	181	191	240	307	381	409	425	409	393	332	228	176	316
Avg:	206	225	271	326	392	419	436	428	404	348	279	218	329
Max:	233	261	290	345	403	427	452	440	416	360	296	252	339

TABLE 8. Riyadh (OERY), Jan 1981– Dec 1990: Highest Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Max.
Year													
1981:	310	320	350	390	430	460	460	460	420	380	330	290	460
1982:	305	260	340	400	424	442	448	446	434	410	310	274	448
1983:	274	300	310	360	422	458	456	456	423	386	332	296	458
1984:	280	292	354	392	424	428	445	432	432	384	314	290	445
1985:	298	285	370	374	424	430	443	468	432	393	332	290	468
1986:	260	295	366	374	450	432	470	465	432	400	334	260	470
1987:	286	330	340	408	420	450	480	468	435	410	340	290	480
1988:	280	290	345	390	430	462	460	460	440	392	330	294	462
1989:	250	300	340	360	436	448	460	450	440	390	348	290	460
1990:	265	280	340	406	450	450	460	444	440	390	328	300	460
Min:	250	260	310	360	420	428	443	432	420	380	310	260	445
Avg:	281	295	346	385	431	446	458	455	433	394	330	287	461
Max:	310	330	370	408	450	462	480	468	440	410	348	300	480

TABLE 9. Riyadh (OERY): Minimum and Maximum Temperature for Every Day of 1987 (Celsius*10)

Month:	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Day:																								
01:	70	170	110	280	160	220	130	260	250	416	268	380	290	450	330	*460	275	400	280	400	215	330	130	260
02:	86	190	104	270	160	300	140	296	254	414	260	410	290	452	330	*450	270	414	260	400	210	330	134	240
03:	84	220	120	280	160	260	170	340	280	410	274	410	288	450	329	*450	270	420	260	410	200	340	130	230
04:	80	200	116	270	139	245	200	340	280	420	284	420	270	440	328	*435	263	410	274	400	180	275	132	220
05:	90	230	120	224	110	230	170	260	280	410	286	410	280	440	318	430	270	428	265	400	160	292	150	230
06:	120	270	100	222	165	285	144	265	280	420	280	400	280	448	305	435	272	430	270	370	170	304	148	274
07:	100	196	110	240	170	265	142	270	254	371	280	400	285	450	300	454	270	418	254	364	174	330	124	200
08:	56	190	120	260	144	300	160	270	240	400	274	420	280	440	310	*445	276	420	246	380	150	270	100	204
09:	100	195	164	300	170	300	190	320	250	400	270	430	300	430	320	*451	280	430	220	340	142	280	90	230
10:	100	230	130	250	178	290	175	340	280	418	270	430	280	430	324	*450	270	435	215	340	140	290	120	212
11:	100	200	10^	210	200	310	190	320	275	400	270	420	280	435	335	*454	275	430	207	350	136	260	90	228
12:	65	178	80	210	135	265	170	330	275	380	260	400	300	440	321	*450	290	418	250	363	120	280	93	250
13:	40	180	84	230	170	280	200	350	270	390	280	430	300	450	320	*452	270	420	240	370	140	318	130	290
14:	65	186	74	238	130	220	220	360	279	398	280	430	299	450	274	453	280	394	249	380	152	305	124	230
15:	60	190	80	250	112	248	237	380	290	414	250	430	300	450	303	*462	270	394	250	380	144	282	110	220
16:	70	214	110	290	170	310	230	386	300	410	284	430	290	440	310	*468	270	400	244	350	146	280	106	224
17:	56	210	135	310	180	304	234	380	290	400	280	410	290	450	324	*436	270	410	240	350	130	290	110	240
18:	44	220	166	280	164	320	250	390	310	410	286	414	280	448	320	*443	280	410	230	360	140	270	110	240
19:	67	220	144	250	180	340	240	400	298	405	280	420	290	440	320	431	284	420	237	350	120	270	135	270
20:	60	230	150	279	150	290	200	290	273	394	270	430	290	450	300	415	280	430	229	360	130	272	140	252
21:	60	254	128	240	160	260	185	300	250	410	272	420	300	*460	280	432	264	400	223	340	140	278	130	230
22:	50	250	110	220	120	200	174	320	275	402	260	403	280	460	290	430	280	398	217	342	144	286	140	240
23:	84	260	70	220	94	140	200	340	300	400	265	410	290	460	292	430	280	418	229	350	150	300	150	270
24:	120	270	120	250	90	220	220	380	275	400	264	414	286	*470	280	420	265	420	220	340	150	300	120	212
25:	120	270	140	280	135	300	250	400	300	390	270	410	300	*480	233	420	280	415	220	340	155	280	90	210
26:	150	286	200	300	160	272	230	390	270	410	262	420	300	*470	280	424	270	400	210	330	144	246	130	230
27:	130	220	170	320	130	225	234	380	270	410	270	420	280	*475	270	400	260	400	200	281	135	250	158	250
28:	90	190	160	330	114	220	210	350	290	390	270	435	330	*470	270	401	250	410	178	277	140	300	120	220
29:	100	210	...	...	130	163	220	380	288	390	298	450	350	*470	270	400	250	400	180	320	140	290	80	150
30:	100	250	...	...	130	210	255	408	300	412	290	440	352	*465	270	430	260	400	227	322	143	271	60	130
31:	100	275	...	...	107	215	...	...	290	410	...	...	330	*455	265	412	...	...	225	330	...	...	58	160

*: Daily Mean Temperature 100F or greater [(Min + Max)/2 > 37.7C]

TABLE 10. Extreme Temperatures (°C) by Month from Available Sources for Riyadh

Type of Extreme	Month	1 BMOT 1941-1945	2 Billions 1958-1969	3 OCDS 1973-1982	4 ISMCS 1973-1989	5 AWS 1977-1984	6 Current 1981-1990	Most Extreme Value
Maximum								
	JAN	30.0		30.0	31.1	31.1	31.0	31.1
	FEB	32.8		32.8	35.0	35.0	33.0	35.0
	MAR	38.3		37.2	37.8	37.8	37.0	38.3*
	APR	40.0	41.7	42.2	42.2	42.2	40.8	42.2
	MAY	43.3	42.8	45.0	47.8	43.9	45.0	47.8
	JUN	45.0	46.1	45.0	47.8	46.1	46.2	47.8
	JUL	45.0	46.1	47.2	47.2	47.2	48.0	48.0
	AUG	44.4	45.0	48.9	47.8	46.1	46.8	48.9
	SEP	43.9	42.8	45.0	43.9	43.9	44.0	45.0
	OCT	38.3	38.9	38.9	41.1	41.1	41.0	41.1
	NOV	34.4		32.8	35.0	33.9	34.8	35.0
	DEC	30.6		28.9	30.0	30.0	30.0	30.6*
	ANN	45.0	46.1	48.9	47.8	47.2	48.0	48.9
Minimum								
	JAN	-7.2			-1.1	1.1	-0.5	-7.2*
	FEB	-1.7			0.0	2.8	0.0	-1.7*
	MAR	0.6			0.0	5.0	4.9	0.0
	APR	2.2			11.1	11.7	11.0	2.2*
	MAY	15.0			15.0	17.8	18.0	15.0
	JUN	19.4			20.0	21.1	21.0	19.4*
	JUL	19.4			21.1	22.8	24.0	19.4*
	AUG	16.7			21.1	22.8	22.7	16.7*
	SEP	17.2			16.1	20.0	16.1	16.1
	OCT	10.0			11.1	12.8	13.0	10.0*
	NOV	1.7			7.2	6.1	7.0	1.7*
	DEC	0.0			1.1	1.1	1.0	0.0*
	ANN	-7.2			0.0	1.1	-0.5	-7.2*

1 BMOT: British Meteorological Office Tables
2 Billions: U.S. Army Missile Command Technical Report 72-13 (see Billions, 1972)
3 OCDS: Operational Climatic Data Summary
4 ISMCS: International Station Meteorological Climate Summary (Compact Disc)
5 AWS: Air Weather Service Climatic Brief
6 Current: The data set analyzed in this report
* Different location for earliest period of record

TABLE 11. Dhahran (OEDR), Jan 1981 – Dec 1990: (a) Relative Frequencies of Hourly Temperatures (percent), (b) 95% and 99% Temperatures (Celsius), by Month

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temp. Class													
-4..-3C:	.	.	.	.	.	.	.	.	.	.	.	.	.
-2..-1C:	.	.	.	.	.	.	.	.	.	.	.	.	.
0..+1C:	.	.	.	.	.	.	.	.	.	.	.	.	.
2..+3C:	0.11	0.02	.	.	.	.	.	.	.	.	.	.	0.01
4..+5C:	0.74	0.37	.	.	.	.	.	.	.	.	.	0.01	0.09
6..+7C:	2.70	1.40	0.07	.	.	.	.	.	.	.	.	0.58	0.39
8..+9C:	7.43	3.63	0.61	.	.	.	.	.	.	.	0.01	3.45	1.26
10..11C:	12.08	8.68	1.67	0.03	.	.	.	.	.	.	0.14	8.44	2.56
12..13C:	15.27	12.13	4.68	0.26	.	.	.	.	.	.	1.71	11.08	3.73
14..15C:	16.53	15.12	8.82	0.64	.	.	.	.	.	0.05	3.53	14.72	4.91
16..17C:	16.65	20.31	11.94	2.71	0.01	.	.	.	.	0.66	8.90	16.09	6.36
18..19C:	14.73	16.37	18.27	6.24	0.18	.	.	.	0.01	2.47	13.00	15.97	7.22
20..21C:	9.37	12.38	18.11	11.26	0.75	0.01	.	.	0.10	5.19	14.15	13.11	7.00
22..23C:	3.62	6.52	14.61	15.15	2.54	0.26	.	0.01	1.42	9.73	16.68	8.67	6.58
24..25C:	0.62	2.23	10.13	17.37	7.34	1.57	0.09	0.56	6.49	14.72	15.26	5.12	6.79
26..27C:	0.14	0.70	6.09	14.68	12.06	5.43	1.95	2.78	12.71	14.89	12.85	2.12	7.21
28..29C:	0.01	0.12	2.94	11.90	15.63	11.03	8.40	9.29	14.06	15.05	7.92	0.59	8.11
30..31C:	.	0.03	1.14	8.69	15.12	13.65	13.12	15.19	14.39	12.86	4.30	0.05	8.26
32..33C:	.	.	0.53	5.43	12.66	13.74	14.17	15.66	12.00	9.89	1.24	.	7.16
34..35C:	.	.	0.31	3.36	11.24	14.17	13.05	13.31	10.75	7.50	0.25	.	6.20
36..37C:	.	.	0.11	1.39	9.40	13.94	11.10	11.52	10.76	4.64	0.06	.	5.27
38..39C:	.	.	.	0.71	6.98	12.43	11.59	12.69	10.26	1.65	.	.	4.72
40..41C:	.	.	.	0.10	4.01	8.24	12.98	12.22	5.50	0.62	.	.	3.67
42..43C:	.	.	.	0.07	1.60	4.31	9.87	5.15	1.38	0.07	.	.	1.89
44..45C:	.	.	.	.	0.35	1.11	3.16	1.33	0.17	.	.	.	0.52
46..47C:	.	.	.	.	0.11	0.11	0.51	0.30	0.01	.	.	.	0.09
48..49C:	.	.	.	.	0.04	.	0.01	.	.	.	.	.	0.00
49..50C:	.	.	.	.	.	.	.	.	.	.	.	.	.
T95:	21.4	22.9	27.5	33.9	40.1	41.7	43.2	42.2	40.2	36.4	29.9	24.6	40.1C
T99:	23.4	25.4	31.4	37.3	42.9	43.9	45.2	44.4	42.3	39.1	32.4	27.2	43.1C

TABLE 12. Dhahran (OEDR), Jan 1981 – Dec 1990: Average Hourly Temperatures by Month (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LST												
0000	131	142	178	227	281	306	316	310	284	250	203	151
0100	126	138	174	222	276	302	311	306	277	244	198	146
0200	123	134	171	219	272	299	309	304	274	239	193	142
0300	118	129	167	212	266	294	305	301	271	236	191	141
0400	116	127	163	210	264	290	305	300	267	233	186	137
0500	112	125	162	209	261	287	304	297	265	229	183	134
0600	110	127	160	207	264	289	304	296	263	225	178	131
0700	107	1 [illegible]	165	222	284	308	323	312	277	235	183	130
0800	118	1 [illegible]	184	244	309	333	348	336	304	261	201	143
0900	136	1	203	266	331	358	373	361	331	287	224	161
1000	157	.	220	284	351	378	396	384	356	310	246	182
1100	174	19.	233	297	364	392	411	400	375	327	262	198
1200	185	201	242	305	371	398	418	407	386	337	272	210
1300	193	208	247	308	374	402	421	410	390	343	278	217
1400	196	210	248	308	372	399	419	409	388	341	278	219
1500	195	208	246	303	367	394	414	403	382	336	273	217
1600	188	202	238	294	359	386	406	395	372	326	264	209
1700	178	192	228	283	347	376	395	384	358	312	251	197
1800	167	179	216	270	333	364	381	369	342	297	239	186
1900	158	170	205	257	318	348	363	353	327	286	231	178
2000	153	165	199	249	309	337	351	343	317	279	225	171
2100	147	160	194	244	302	329	341	336	309	272	220	166
2200	141	154	189	237	294	321	331	327	300	265	214	161
2300	136	149	183	232	288	313	322	318	292	257	208	155

TABLE 13. Dhahran (OEDR), Jan 1981 –Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10)

"Five-Day" Period	Daily Low Min	Daily Low Avg	Daily Low Max	Daily Low SD	Daily Mean Min	Daily Mean Avg	Daily Mean Max	Daily Mean SD	Daily High Min	Daily High Avg	Daily High Max	Daily High SD	Smoothed Avg. Low	Smoothed Avg. Mean	Smoothed Avg. High
JAN 01--05:	52	100	180	27	80	152	202	22	110	203	270	24	102	152	204
JAN 06--10:	28	99	153	27	82	150	203	24	133	201	250	27	98	149	201
JAN 11--15:	26	94	170	25	89	144	195	24	108	198	280	30	96	147	199
JAN 16--20:	18	91	160	30	97	144	204	28	130	198	280	30	96	147	199
JAN 21--25:	40	99	180	36	100	151	209	28	132	201	290	27	98	149	200
JAN 26--31:	42	100	180	30	98	150	203	23	150	198	261	24	99	151	202
FEB 01--05:	38	99	185	32	97	154	223	26	140	208	270	28	103	154	206
FEB 06--10:	32	114	170	31	103	162	210	26	130	212	270	28	106	158	210
FEB 11--15:	40	104	170	23	117	158	201	17	170	216	295	25	110	162	214
FEB 16--20:	56	116	164	26	123	171	206	19	170	226	298	26	114	166	219
FEB 21--25:	50	123	170	27	115	174	215	20	150	223	280	26	119	172	224
FEB 26--28:	60	120	176	30	137	173	229	25	170	225	290	28	125	177	230
MAR 01--05:	64	130	190	32	119	183	228	26	160	238	320	33	131	183	237
MAR 06--10:	72	140	210	33	141	194	275	33	180	251	360	42	138	191	244
MAR 11--15:	65	152	200	28	137	201	256	25	155	251	325	35	145	197	251
MAR 16--20:	90	148	200	26	155	203	267	25	200	261	370	37	152	205	259
MAR 21--25:	93	162	230	31	169	218	266	25	220	274	360	32	159	212	266
MAR 26--31:	98	167	230	30	159	216	276	27	190	267	360	36	167	221	276
APR 01--05:	100	174	250	30	181	227	306	26	220	283	370	35	174	229	286
APR 06--10:	140	182	250	22	207	241	295	21	250	299	370	30	183	240	299
APR 11--15:	150	201	250	22	224	262	314	20	270	327	430	35	191	249	309
APR 16--20:	110	198	250	30	192	258	311	25	230	320	415	37	199	259	321
APR 21--25:	130	210	267	23	225	274	316	21	270	340	400	35	206	267	329
APR 26--30:	150	210	250	24	219	269	320	20	270	329	405	29	214	275	338
MAY 01--05:	140	224	270	29	240	287	330	22	280	350	420	31	221	284	346
MAY 06--10:	170	235	280	23	255	296	345	19	310	357	440	28	230	294	357
MAY 11--15:	198	239	285	20	273	306	335	15	315	371	420	24	238	303	368
MAY 16--20:	190	246	290	22	270	317	361	19	310	385	440	27	245	313	379
MAY 21--25:	210	259	310	23	289	329	376	17	340	399	460	28	253	322	388
MAY 26--31:	210	263	330	23	297	333	382	16	340	401	480	25	259	328	396
JUN 01--05:	210	263	330	24	295	336	376	16	342	407	470	26	264	333	400
JUN 06--10:	218	279	340	25	293	347	390	19	350	410	470	27	268	336	402
JUN 11--15:	220	275	328	23	310	341	381	16	360	407	470	27	271	338	403
JUN 16--20:	230	273	310	18	306	340	367	14	360	406	452	23	273	340	404
JUN 21--25:	220	277	330	22	304	339	374	14	360	400	440	19	276	342	406
JUN 26--30:	230	281	348	24	316	348	380	13	360	414	450	21	278	344	409
JUL 01--05:	240	286	330	19	320	352	381	15	370	419	460	22	281	346	412
JUL 06--10:	245	285	334	20	328	351	381	12	370	420	460	20	283	349	416
JUL 11--15:	240	290	348	21	332	354	384	12	370	421	470	20	285	351	419
JUL 16--20:	245	287	330	18	321	354	383	13	370	428	470	22	287	352	420
JUL 21--25:	245	291	348	20	325	359	388	13	390	430	470	20	287	352	421
JUL 26--31:	250	292	340	21	331	356	396	14	370	423	480	20	287	352	419

TABLE 13. Dhahran (OEDR), Jan 1981 –Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10) (cont'd)

"Five-Day" Period	Daily Low Min	Daily Low Avg	Daily Low Max	Daily Low SD	Daily Mean Min	Daily Mean Avg	Daily Mean Max	Daily Mean SD	Daily High Min	Daily High Avg	Daily High Max	Daily High SD	Smoothed Avg. Low	Smoothed Avg. Mean	Smoothed Avg. High
AUG 01--05:	255	292	340	18	331	353	371	10	370	418	452	18	286	350	417
AUG 06--10:	250	287	320	18	335	352	381	11	390	421	470	20	284	348	414
AUG 11--15:	239	283	320	18	324	348	382	11	370	414	470	21	282	345	411
AUG 16--20:	240	282	315	16	319	345	368	10	370	411	450	19	278	341	408
AUG 21--25:	240	278	325	20	307	342	372	15	360	410	470	21	274	338	406
AUG 26--31:	228	273	320	22	310	336	378	14	370	404	450	20	269	333	402
SEP 01--05:	232	263	302	17	302	330	356	12	360	400	450	20	264	329	399
SEP 06--10:	225	262	320	19	297	330	367	14	350	405	460	22	258	324	396
SEP 11--15:	210	253	295	16	299	322	348	11	350	397	440	20	253	319	392
SEP 16--20:	216	250	296	17	287	316	342	12	350	388	430	21	247	314	387
SEP 21--25:	210	244	290	15	283	310	344	12	335	383	430	22	242	308	381
SEP 26--30:	190	239	280	18	275	307	330	13	330	383	430	21	236	302	375
OCT 01--05:	190	230	280	16	260	299	332	14	318	374	430	23	231	296	367
OCT 06--10:	179	231	280	20	256	294	323	16	310	362	410	23	225	289	359
OCT 11--15:	145	223	270	21	248	284	309	16	290	350	400	20	219	282	349
OCT 16--20:	170	212	240	19	216	277	302	18	260	347	390	26	213	273	339
OCT 21--25:	146	211	270	28	202	269	304	24	253	331	400	27	206	265	328
OCT 26--31:	130	198	270	22	217	258	303	16	279	320	370	23	198	256	316
NOV 01--05:	150	194	233	18	216	248	283	16	240	305	368	23	190	246	305
NOV 06--10:	135	185	232	21	195	241	287	17	250	298	365	20	181	236	293
NOV 11--15:	111	175	235	28	158	226	270	26	200	281	330	30	172	226	283
NOV 16--20:	108	160	210	23	166	216	262	19	215	275	330	25	162	216	273
NOV 21--25:	110	150	200	19	155	204	240	20	200	263	310	26	152	206	263
NOV 26--30:	90	150	218	24	134	204	250	21	170	260	330	25	144	198	253
DEC 01--05:	70	138	210	32	92	191	245	31	110	244	300	34	136	189	244
DEC 06--10:	60	121	185	30	103	175	230	31	150	230	290	37	129	181	235
DEC 11--15:	60	128	191	28	111	180	223	24	153	231	300	29	123	174	227
DEC 16--20:	70	119	190	31	118	167	224	30	150	219	270	31	117	168	220
DEC 21--25:	50	111	190	32	125	164	220	24	150	218	302	24	111	162	214
DEC 26--31:	50	105	170	29	103	155	202	24	150	207	270	26	107	157	209

TABLE 14. Dhahran (OEDR), Jan 1981 – Dec 1990: Lowest Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-M Min.
Year													
1981:	50	50	90	100	190	220	260	240	190	160	110	80	50
1982:	18	63	96	118	200	220	245	250	230	195	90	60	18
1983:	50	45	64	133	205	260	258	228	216	145	141	70	45
1984:	54	53	78	154	174	233	250	239	210	146	130	70	53
1985:	70	50	72	148	210	218	263	255	219	160	145	64	50
1986:	40	70	112	170	202	238	255	259	229	180	108	60	40
1987:	60	83	93	125	210	240	255	240	216	184	120	66	60
1988:	52	73	110	150	212	246	265	256	212	185	111	59	52
1989:	26	32	112	124	208	210	262	264	214	188	148	81	26
1990:	62	60	82	140	198	232	258	248	216	190	146	50	50
Min:	18	32	64	100	174	210	245	228	190	145	90	50	18
Avg:	48	58	91	136	201	232	257	248	215	173	125	66	44
Max:	70	83	112	170	212	260	265	264	230	195	148	81	60

TABLE 15. Dhahran (OEDR), Jan 1981 – Dec 1990: Average Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	125	117	159	185	234	256	288	275	249	211	159	122	199
1982:	89	99	146	190	245	271	269	285	260	236	154	97	196
1983:	89	101	121	186	259	289	285	288	243	192	167	116	195
1984.	88	110	165	207	233	275	286	276	248	203	182	115	199
1985:	122	103	141	191	248	270	291	278	249	210	182	127	202
1986:	95	115	149	202	253	273	285	292	259	227	173	107	203
1987:	95	118	153	191	245	274	290	292	256	231	162	127	203
1988:	93	119	157	206	251	274	292	288	260	224	162	128	205
1989:	69	87	147	191	249	272	289	287	250	210	187	117	197
1990:	99	119	145	198	244	271	293	276	254	222	173	129	202
Min:	69	87	121	185	233	256	269	275	243	192	154	97	195
Avg:	96	109	148	195	246	273	287	284	253	217	170	119	200
Max:	125	119	165	207	259	289	293	292	260	236	187	129	205

TABLE 16. Dhahran (OEDR), Jan 1981–Dec 1990: Mean Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	169	170	212	251	304	332	356	345	319	275	221	180	262
1982:	149	146	185	251	310	344	348	346	325	289	198	144	254
1983:	134	151	173	238	316	348	354	345	313	257	225	172	253
1984:	148	168	216	269	299	341	357	339	314	268	234	162	260
1985:	169	158	197	256	316	337	354	347	319	276	235	173	262
1986:	150	166	203	255	321	342	358	353	329	294	225	155	263
1987:	152	181	205	256	322	345	364	351	325	289	223	181	267
1988:	146	168	206	261	319	347	358	357	328	291	222	182	266
1989:	128	147	206	255	321	338	358	355	316	279	238	165	259
1990:	142	167	204	257	322	344	362	346	324	286	230	186	265
Min:	128	146	173	238	299	332	348	339	313	257	198	144	253
Avg:	149	162	201	255	315	342	357	348	321	280	225	170	261
Max:	169	181	216	269	322	348	364	357	329	294	238	186	267

TABLE 17. Dhahran (OEDR), Jan 1981 - Dec 1990: Average Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	212	221	267	313	362	405	426	412	393	338	286	242	324
1982:	199	189	224	311	369	406	421	410	399	346	240	190	309
1983:	183	203	223	290	374	403	424	405	387	327	284	228	311
1984:	207	226	269	330	364	404	427	402	387	341	283	208	321
1985:	219	215	253	320	382	403	414	423	395	344	291	216	323
1986:	203	213	259	307	383	397	428	414	401	360	274	205	321
1987:	212	243	255	321	395	411	435	412	397	345	293	233	330
1988:	197	213	259	320	383	412	424	427	403	363	287	235	328
1989:	181	202	263	318	383	401	430	427	387	347	292	212	321
1990:	184	215	259	316	394	412	432	412	398	354	294	255	328
Min:	181	189	223	290	362	397	414	402	387	327	240	190	309
Avg:	200	214	253	315	379	405	426	414	395	347	282	222	322
Max:	219	243	269	330	395	412	435	427	403	363	294	255	330

TABLE 18. Dhahran (OEDR), Jan 1981 – Dec 1990: Highest Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Max.
Year													
1981:	250	270	340	370	430	450	450	450	420	390	330	290	450
1982:	230	240	270	390	430	450	450	440	440	410	290	260	450
1983:	250	251	280	350	430	450	470	440	420	390	310	290	470
1984:	250	295	360	405	420	431	460	430	430	410	310	260	460
1985:	280	270	350	390	430	440	450	470	430	410	330	280	470
1986:	235	260	350	350	480	433	470	450	430	430	365	270	480
1987:	261	298	370	415	440	452	480	470	430	410	368	270	480
1988:	230	260	360	390	440	470	470	460	460	400	360	270	470
1989:	220	252	330	400	440	450	460	470	440	400	350	295	470
1990:	240	280	300	430	460	450	470	440	430	390	340	302	470
Min:	220	240	270	350	420	431	450	430	420	390	290	260	450
Avg:	245	268	331	389	440	448	463	452	433	404	335	279	467
Max:	280	298	370	430	480	470	480	470	460	430	368	302	480

TABLE 19. Dhahran (OEDR): Minimum and Maximum Temperature of Every Day of 1987 (Celsius*10)

Month:	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Day:																								
01:	80	170	110	270	190	250	125	260	230	420	260	390	305*440		308	410	238	400	230	380	228	320	160	270
02:	100	187	120	260	173	277	135	270	220	395	240	405	290*450		290	400	232	395	238	390	210	350	160	252
03:	82	200	94	250	179	290	148	290	226	370	250	410	290	440	275	420	242	410	245	400	220	368	151	250
04:	109	205	108	240	170	260	206	300	232	390	259	400	285	430	302	410	265	390	222	370	190	282	135	250
05:	85	220	130	230	130	230	190	240	238	390	270	380	270	430	302*452		270	400	250	360	162	290	158	265
06:	110	220	110	230	120	250	173	250	232	440	286	370	282	430	300*450		280	410	280	400	158	300	172	240
07:	110	210	100	230	163	270	170	260	250	375	272	390	255	430	320*430		275	395	245	395	155	310	140	230
08:	90	200	88	210	175	230	165	260	230	380	275	390	265	430	302	400	273	400	238	410	180	289	100	205
09:	91	200	155	260	168	280	162	280	210	350	272	430	258	430	300	410	270	420	210	336	160	270	80	210
10:	82	200	150	240	190	290	162	295	220	370	310	390	298	440	309	410	255	430	203	330	168	280	100	220
11:	110	210	110	220	170	295	171	313	232	350	274	390	290	430	302*440		261	430	205	340	158	270	88	230
12:	92	190	94	210	150	250	184	310	214	360	290	390	310	427	294*470		262	370	202	335	134	270	106	240
13:	96	210	90	230	142	270	176	330	253	380	262	410	310*430		310*470		260	390	230	330	150	290	114	257
14:	98	200	83	223	136	215	189	350	265	390	252	430	300	430	315	415	250	380	270	330	160	300	130	240
15:	70	192	100	250	123	220	192	370	250	400	274	440	286	410	300	405	285	390	246	350	170	300	128	230
16:	68	210	108	298	160	300	211	350	238	350	270	440	290	430	310	390	249	391	210	330	160	300	122	230
17:	80	210	138	265	200	350	215	370	236	400	264	450	273	410	290	390	240	350	230	320	170	280	110	250
18:	80	217	140	220	184	285	210	415	249	420	292*452		280	430	268	410	265	350	236	333	150	290	100	222
19:	85	230	112	260	180	370	250	380	268	410	306	420	279*470		292	410	280	385	238	335	144	300	136	230
20:	70	232	142	245	185	232	222	273	280	390	293	420	290	430	310	410	278	430	234	350	135	290	130	220
21:	62	230	130	220	160	230	207	270	252	410	295	394	280	430	284	410	270	390	223	355	170	290	156	235
22:	60	210	83	220	149	220	196	280	258	430	280	390	261	420	275	410	216	410	255	320	154	310	154	249
23:	105	190	102	233	110	220	193	345	250	390	270	390	280	450	286	415	240	430	270	340	156	310	181	250
24:	110	220	121	240	93	250	210	375	232	410	256	400	310*430		302	420	260	395	242	340	161	310	150	240
25:	118	240	110	253	103	250	190	390	250	420	272	410	260	470	302	390	232	410	234	340	170	290	125	220
26:	133	261	148	250	190	230	220	380	263	430	278	395	284*465		296	380	240	410	270	350	160	260	130	250
27:	131	230	176	275	150	230	198	350	266	420	266	440	293*480		288	370	251	410	210	291	130	250	156	250
28:	130	195	166	280	116	240	220	330	270	393	265	450	328*445		262	372	246	405	200	290	120	270	160	260
29:	110	210	...	...	140	190	220	355	263	410	275	440	340*420		264	400	245	370	184	313	134	270	80	180
30:	85	230	...	...	130	200	222	390	253	430	288	410	321*420		260	395	239	370	201	305	146	265	66	190
31:	102	250	...	...	108	240	...	...	280	380	...	...	318	420	240	410	...	...	210	315	...	...	68	180

*: Daily Mean Temperature 100F or greater [(Min + Max)/2 >37.7 C]

TABLE 20. Extreme Temperatures (°C) by Month from Available Sources for Dhahran

Type of Extreme	Month	1 RUSSWO 1946-1962	2 AWS 1961-1987	3 LSOCS 1973-1984	4 ISMCS 1973-1989	5 Current 1981-1990	Most Extreme Value
Maximum							
	JAN	35.6	35.6	28.9	28.9	28.0	35.6
	FEB	33.3	35.6	30.0	36.1	29.8	35.6
	MAR	37.2	37.8	36.1	37.2	37.0	37.8
	APR	43.3	45.0	42.8	42.8	43.0	45.0
	MAY	46.7	47.8	47.2	47.8	48.0	48.0
	JUN	46.7	48.9	47.2	47.2	47.0	48.9
	JUL	47.8	48.9	47.2	48.9	48.0	48.9
	AUG	48.9	51.1	45.0	47.2	47.0	51.1
	SEP	46.7	47.8	45.0	46.1	46.0	47.8
	OCT	44.4	44.4	41.1	42.8	43.0	44.4
	NOV	37.2	37.2	36.1	36.7	36.8	37.2
	DEC	30.6	32.2	30.0	30.0	30.2	32.2
	ANN	48.9	51.1	47.2	48.9	48.0	51.1
Minimum							
	JAN	1.7	-0.5	2.2	2.2	1.8	-0.5
	FEB	2.8	1.1	5.0	1.1	3.2	1.1
	MAR	7.8	5.0	7.2	7.2	6.4	5.0
	APR	11.1	10.0	10.0	10.0	10.0	10.0
	MAY	17.1	15.0	16.1	15.0	17.4	15.0
	JUN	19.4	19.4	21.1	20.0	21.0	19.4
	JUL	23.3	21.1	21.7	20.0	24.5	20.0
	AUG	24.4	22.2	22.8	21.1	22.8	21.1
	SEP	21.1	18.9	18.9	18.9	19.0	18.9
	OCT	15.6	12.2	13.9	13.9	14.5	12.2
	NOV	10.0	7.8	10.0	8.9	9.0	7.8
	DEC	4.4	3.3	2.8	2.8	5.0	2.8
	ANN	1.7	-0.5	2.2	1.1	1.8	-0.5

[1] RUSSWO: Revised Uniform Summary of Surface Weather Observations
[2] AWS: Air Weather Service Climatic Brief
[3] LSOCS: Limited Surface Observations Climatic Summary
[4] ISMCS: International Station Meteorological Climate Summary (Compact Disc)
[5] Current: The data set analyzed in this report

TABLE 21. Qaisumah (OEPA), Jan 1981 – Dec 1990: (a) Relative Frequencies of Hourly Temperatures (percent), (b) 95% and 99% Temperatures (Celsius), by Month

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Temp. Class													
-4..-3C:	0.01	.	.	.	.	.	.	.	.	.	.	.	0.00
-2..-1C:	0.16	0.08	.	.	.	.	.	.	.	.	.	0.01	0.02
0.. 1C:	0.62	0.49	0.05	.	.	.	.	.	.	.	.	0.38	0.13
2.. 3C:	2.46	1.12	0.22	.	.	.	.	.	.	.	0.06	1.45	0.44
4.. 5C:	6.63	3.30	0.44	.	.	.	.	.	.	.	0.22	4.09	1.22
6.. 7C:	12.18	6.67	0.98	.	.	.	.	.	.	0.01	1.18	7.51	2.37
8.. 9C:	15.23	11.65	2.88	0.07	.	.	.	.	.	0.08	2.70	11.64	3.65
10..11C:	16.53	14.20	6.01	0.31	.	.	.	.	.	0.16	4.60	13.98	4.61
12..13C:	14.97	15.18	9.81	0.96	.	.	.	.	.	0.32	7.60	15.34	5.30
14..15C:	12.02	13.23	12.57	2.99	0.04	.	.	.	.	1.41	12.08	14.44	5.69
16..17C:	8.70	11.59	14.54	5.93	0.19	.	.	.	.	3.09	15.18	10.79	5.79
18..19C:	5.28	9.29	12.80	9.32	0.66	.	.	.	0.18	5.87	14.72	7.43	5.43
20..21C:	2.73	6.65	12.88	10.93	2.22	0.01	.	.	0.85	9.05	11.64	5.65	5.20
22..23C:	1.69	3.33	9.93	13.00	4.73	0.90	0.04	0.35	2.61	12.16	9.83	3.33	5.16
24..25C:	0.66	1.68	7.10	12.89	9.10	4.82	0.66	1.96	7.50	13.00	7.14	2.11	5.73
26..27C:	0.12	1.03	4.70	12.67	11.53	9.46	4.06	5.43	11.54	11.36	5.35	1.18	6.55
28..29C:	0.01	0.39	2.88	10.19	11.90	10.69	9.24	9.79	12.14	10.15	3.85	0.57	6.84
30..31C:	.	0.13	1.43	7.81	11.09	10.06	11.31	10.75	10.22	9.09	2.28	0.11	6.22
32..33C:	.	.	0.46	5.97	10.91	9.78	10.19	10.67	9.10	8.44	1.19	.	5.60
34..35C:	.	.	0.27	4.08	10.59	9.63	9.57	9.89	8.58	6.64	0.39	.	5.00
36..37C:	.	.	0.07	1.75	9.83	10.64	8.43	9.43	9.79	5.65	.	.	4.66
38..39C:	.	.	.	0.92	8.56	12.65	9.28	10.70	10.92	2.73	.	.	4.67
40..41C:	.	.	.	0.17	5.67	11.90	12.44	11.71	9.17	0.66	.	.	4.33
42..43C:	.	.	.	0.06	2.50	6.64	14.00	10.75	6.04	0.13	.	.	3.37
44..45C:	.	.	.	.	0.44	2.28	8.31	6.18	1.33	.	.	.	1.57
46..47C:	.	.	.	.	0.04	0.49	2.33	2.20	0.03	.	.	.	0.43
48..49C:	.	.	.	.	.	0.06	0.15	0.17	.	.	.	.	0.03
49..50C:	.	.	.	.	.	.	.	.	.	.	.	.	.
T95:	19.7	22.4	27.6	34.5	40.8	42.8	44.9	44.7	42.3	37.0	28.9	22.9	41.7C
T99:	23.3	26.6	31.2	37.8	43.1	45.1	46.8	46.8	44.0	39.3	32.5	26.9	44.8C

TABLE 22. Qaisumah (OEPA), Jan 1981 – Dec 1990: Average Hourly Temperatures by Month (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LST												
0000	95	114	158	220	282	305	327	321	292	235	162	110
0100	90	108	151	212	273	296	318	312	282	226	156	105
0200	84	102	146	206	265	284	308	303	274	220	152	100
0300	79	95	140	199	258	276	299	295	269	217	146	97
0400	74	91	135	194	253	269	290	291	260	212	143	94
0500	72	87	131	188	247	263	283	283	257	206	138	88
0600	68	83	127	183	242	259	280	274	248	202	135	87
0700	68	81	129	190	256	279	299	288	257	203	136	84
0800	74	95	144	213	285	314	332	319	284	227	147	90
0900	89	112	166	238	308	340	361	350	321	257	172	111
1000	111	136	188	257	332	363	389	378	350	287	198	136
1100	131	155	205	274	347	380	407	398	372	306	219	156
1200	146	170	218	289	359	391	416	408	386	322	230	171
1300	157	181	228	296	371	403	425	420	396	332	242	182
1400	163	189	234	307	375	407	432	425	405	335	249	187
1500	170	193	240	308	378	410	434	426	406	342	252	191
1600	167	192	238	306	378	414	436	428	404	339	246	189
1700	160	186	233	300	374	408	432	421	396	329	238	180
1800	147	176	224	292	363	398	421	411	384	312	220	163
1900	131	155	205	272	347	384	405	394	357	287	206	149
2000	122	148	195	261	331	361	387	376	338	274	193	139
2100	114	136	184	249	315	344	367	357	326	262	185	130
2200	108	128	174	238	302	330	353	346	314	251	175	124
2300	100	122	166	229	291	319	340	335	301	242	169	115

TABLE 23. Qaisumah (OEPA), Jan 1981 – Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10)

"Five-Day"	Daily Low				Daily Mean				Daily High				Smoothed Avg.		
Period :	Min	Avg	Max	SD	Min	Avg	Max	SD	Min	Avg	Max	SD	Low	Mean	High
JAN 01--05:	-19	55	108	27	27	110	161	25	78	170	230	33	60	116	177
JAN 06--10:	-28	61	140	32	51	117	201	33	95	183	264	44	58	114	177
JAN 11--15:	9	57	134	31	68	114	184	32	94	178	259	41	57	112	174
JAN 16--20:	-7	52	110	28	62	109	162	25	110	169	240	32	57	113	175
JAN 21--25:	8	59	108	27	57	117	175	27	106	183	280	39	59	115	176
JAN 26--31:	9	62	116	27	57	113	172	26	80	166	245	36	61	118	179
FEB 01--05:	-20	63	140	34	51	123	204	35	114	188	302	44	64	122	184
FEB 06--10:	-3	64	125	33	64	126	208	35	90	188	282	41	67	127	190
FEB 11--15:	9	72	136	27	80	136	205	29	144	203	306	38	71	132	196
FEB 16--20:	26	80	140	26	91	142	224	25	116	206	312	35	76	138	203
FEB 21--25:	-19	77	130	32	76	139	220	29	133	203	312	39	82	145	210
FEB 26--28:	20	82	135	28	88	149	205	29	152	218	290	36	90	152	218
MAR 01--05:	0	104	180	38	69	165	239	39	121	232	324	50	98	160	226
MAR 06--10:	14	110	200	43	96	175	266	42	164	243	360	53	106	168	234
MAR 11--15:	54	115	198	28	120	176	250	28	156	239	320	36	113	176	241
MAR 16--20:	65	121	194	32	128	183	253	31	168	248	340	40	121	184	249
MAR 21--25:	70	130	190	30	129	197	261	28	154	263	335	35	127	191	256
MAR 26--31:	60	129	189	27	123	192	266	31	153	256	371	42	136	201	267
APR 01--05:	80	142	210	27	144	211	269	25	200	279	358	34	146	213	280
APR 06--10:	100	156	219	26	186	223	272	21	242	292	350	26	159	227	295
APR 11--15:	130	181	246	26	206	254	319	27	253	325	426	36	170	239	307
APR 16--20:	136	189	250	32	201	260	315	29	228	328	402	37	183	253	321
APR 21--25:	139	197	252	27	194	266	326	30	225	334	410	42	192	263	332
APR 26--30:	138	194	258	25	203	266	328	26	251	337	430	35	202	273	342
MAY 01--05:	148	219	294	29	237	290	343	30	280	361	430	40	211	282	352
MAY 06--10:	144	219	290	26	222	291	349	26	250	364	432	33	220	293	364
MAY 11--15:	178	230	274	23	265	304	358	20	322	374	428	26	229	304	376
MAY 16--20:	170	242	282	24	264	323	355	21	330	397	445	25	238	316	388
MAY 21--25:	210	251	300	22	301	334	377	19	364	409	462	25	245	324	398
MAY 26--31:	202	257	320	22	290	336	368	17	347	409	454	23	250	332	406
JUN 01--05:	221	260	307	19	311	345	374	17	380	422	473	23	253	336	410
JUN 06--10:	220	259	310	20	303	344	380	17	380	420	456	19	253	337	412
JUN 11--15:	210	255	303	24	314	341	397	22	380	416	484	27	253	338	413
JUN 16--20:	218	248	290	17	309	335	368	13	370	409	445	16	252	339	414
JUN 21--25:	215	248	280	15	310	335	370	13	374	412	456	16	254	341	417
JUN 26--30:	232	260	295	15	315	349	385	17	378	427	470	22	257	345	421
JUL 01--05:	230	265	290	15	328	356	377	12	400	434	461	15	262	350	426
JUL 06--10:	230	274	305	17	321	359	385	14	390	435	470	18	267	355	432
JUL 11--15:	240	273	318	17	327	362	393	15	400	442	472	17	272	359	437
JUL 16--20:	252	278	305	13	337	367	395	13	396	445	475	18	275	362	439
JUL 21--25:	250	287	313	15	348	374	408	15	421	451	498	19	277	363	440
JUL 26--31:	248	281	321	17	339	367	400	17	412	443	495	20	277	363	439
AUG 01--05:	224	277	324	26	319	363	409	21	384	437	482	25	276	361	437
AUG 06--10:	228	282	370	27	321	364	420	23	385	440	490	25	274	359	434
AUG 11--15:	218	268	325	22	316	355	403	18	390	431	474	20	271	356	432
AUG 16--20:	220	274	315	20	307	359	386	19	375	436	472	24	268	353	429
AUG 21--25:	223	270	326	23	314	355	399	22	386	434	483	26	266	350	427
AUG 26--31:	226	262	320	24	308	346	393	21	379	424	470	23	262	346	424

TABLE 23. Qaisumah (OEPA), Jan 1981 – Dec 1990: "Five-Day" Mean and Extreme Temperatures and Standard Deviation (Celsius*10) (cont'd)

"Five-Day" Period :	Daily Low Min	Avg	Max	SD	Daily Mean Min	Avg	Max	SD	Daily High Min	Avg	Max	SD	Smoothed Avg. Low	Mean	High
SEP 01--05 :	193	260	290	18	304	344	374	14	366	426	462	19	259	341	421
SEP 06--10 :	232	268	298	17	307	348	373	15	371	427	454	18	253	335	416
SEP 11--15 :	211	249	280	18	300	331	358	16	380	414	450	18	247	329	411
SEP 16--20 :	183	238	280	18	271	322	343	15	331	406	442	20	239	321	404
SEP 21--25 :	180	228	276	22	273	312	349	17	360	398	450	20	232	313	396
SEP 26--30 :	187	229	280	20	281	312	354	15	366	397	446	18	224	304	387
OCT 01--05 :	190	223	258	16	258	302	339	18	332	386	426	20	216	294	376
OCT 06--10 :	129	210	280	28	213	284	337	27	292	363	412	29	208	283	363
OCT 11--15 :	126	199	245	26	217	271	326	25	269	350	420	34	199	272	351
OCT 16--20 :	94	196	243	33	157	268	300	30	243	346	392	34	189	259	337
OCT 21--25 :	70	175	226	32	148	246	293	30	222	323	385	36	178	247	322
OCT 26--31 :	122	172	230	22	180	240	285	21	206	317	370	30	166	232	305
NOV 01--05 :	102	157	220	23	158	218	261	26	206	288	342	37	154	218	290
NOV 06--10 :	90	147	190	24	157	209	265	29	197	281	350	42	141	203	272
NOV 11--15 :	15	119	180	35	83	174	244	36	126	237	346	44	131	191	260
NOV 16--20 :	54	117	164	27	119	179	234	29	184	251	330	40	120	179	246
NOV 21--25 :	40	111	183	37	96	172	234	39	113	242	322	50	111	170	237
NOV 26--30 :	40	116	177	31	84	175	224	31	139	241	315	40	102	161	227
DEC 01--05 :	20	94	150	36	64	148	214	40	98	210	301	52	94	152	218
DEC 06--10 :	0	75	152	38	69	136	212	40	120	204	300	50	86	144	209
DEC 11--15 :	-2	79	137	30	63	139	211	33	127	208	295	42	79	137	201
DEC 16--20 :	10	73	140	32	76	129	203	33	93	190	292	41	72	130	193
DEC 21--25 :	4	73	130	26	76	132	192	27	133	196	270	35	67	124	187
DEC 26--31 :	-10	58	113	30	48	115	186	30	72	176	286	38	64	120	182

TABLE 24. Qaisumah (OEPA), Jan 1981 – Dec 1990: Lowest Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Min.
Year													
1981:	10	30	60	80	160	210	230	230	200	138	40	50	10
1982:	2	6	60	92	182	216	240	224	220	140	40	-2	-2
1983:	5	16	38	103	188	235	230	228	191	126	111	4	4
1984:	9	20	81	130	144	215	248	218	198	70	108	21	9
1985:	43	-19	0	110	202	224	247	250	181	122	120	6	-19
1986:	8	42	78	140	170	216	232	260	218	140	50	0	0
1987:	10	38	70	113	215	230	270	230	193	139	90	4	4
1988:	18	38	52	110	202	230	252	246	187	171	15	-10	-10
1989:	-28	-20	75	100	196	220	250	250	180	148	50	44	-28
1990:	12	48	65	124	182	232	250	250	208	158	93	2	2
Min:	-28	-20	0	80	144	210	230	218	180	70	15	-10	-28
Avg:	9	20	58	110	184	223	245	239	198	135	72	12	-3
Max:	43	48	81	140	215	235	270	260	220	171	120	50	10

TABLE 25. Qaisumah (OEPA), Jan 1981 – Dec 1990: Average Minimum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	68	82	125	165	215	243	275	270	244	184	117	86	173
1982:	59	49	104	178	241	260	268	252	259	197	92	52	168
1983:	43	58	96	153	240	265	274	269	230	166	139	76	168
1984:	57	76	142	179	217	242	271	239	240	183	145	62	172
1985:	84	61	110	177	241	248	261	276	243	184	147	72	176
1986:	65	84	119	179	230	251	277	290	255	211	112	58	178
1987:	57	100	119	180	262	262	291	290	253	210	127	90	187
1988:	61	84	123	182	234	263	283	279	244	210	124	85	182
1989:	30	54	127	188	245	251	280	275	240	197	134	71	175
1990:	51	72	117	183	240	262	284	273	243	204	136	94	181
Min:	30	49	96	153	215	242	261	239	230	166	92	52	168
Avg:	58	72	118	176	237	255	276	271	245	195	127	75	176
Max:	84	100	142	188	262	265	291	290	259	211	147	94	187

TABLE 26. Qaisumah (OEPA), Jan 1981 – Dec 1990: Mean Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	126	140	191	244	299	337	361	359	331	264	188	155	250
1982:	112	109	163	247	310	345	356	339	343	259	146	104	237
1983:	92	119	160	221	317	345	363	352	313	246	209	139	240
1984:	120	150	204	254	299	331	359	325	321	257	190	116	244
1985:	138	129	174	251	317	337	348	366	325	259	200	126	248
1986:	119	145	184	241	304	333	367	374	339	285	172	118	249
1987:	125	170	175	251	335	346	378	368	335	272	194	149	259
1988:	112	144	189	248	315	349	369	362	328	282	189	138	253
1989:	90	115	193	258	321	340	370	363	321	272	187	122	247
1990:	98	127	183	252	322	352	371	357	327	280	203	156	253
Min:	90	109	160	221	299	331	348	325	313	246	146	104	237
Avg:	113	135	182	247	314	342	364	357	328	268	188	132	248
Max:	138	170	204	258	335	352	378	374	343	285	209	156	259

TABLE 27. Qaisumah (OEPA), Jan 1981 – Dec 1990: Average Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Avg.
Year													
1981:	182	203	260	319	374	414	434	436	413	344	266	229	323
1982:	171	167	223	314	376	419	432	414	426	325	205	158	303
1983:	141	181	222	288	386	415	441	427	394	330	289	206	311
1984:	190	224	269	324	367	407	433	399	403	333	247	174	315
1985:	195	195	241	322	389	416	426	448	410	344	264	183	320
1986:	182	208	250	306	376	406	448	453	422	368	238	190	321
1987:	205	245	235	322	406	423	460	442	419	340	271	214	332
1988:	168	207	259	312	392	428	444	436	414	363	263	202	325
1989:	157	182	263	329	394	418	454	443	403	354	243	179	319
1990:	154	187	250	323	403	431	447	435	411	365	281	230	327
Min:	141	167	222	288	367	406	426	399	394	325	205	158	303
Avg:	175	200	247	316	386	418	442	433	412	347	257	197	320
Max:	205	245	269	329	406	431	460	453	426	368	289	230	332

TABLE 28. Qaisumah (OEPA), Jan 1981 – Dec 1990: Highest Maximum Temperature by Month and Year (Celsius*10)

Month:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	12-Mo. Max.
Year													
1981:	270	280	340	410	430	460	470	490	440	390	340	282	490
1982:	224	254	288	386	424	448	461	440	454	396	272	248	461
1983:	230	239	301	373	435	462	475	468	425	398	330	300	475
1984:	264	306	360	380	421	444	452	428	430	398	310	244	452
1985:	255	259	335	382	436	445	444	478	450	402	322	260	478
1986:	259	268	350	354	454	443	480	483	445	420	334	286	483
1987:	280	312	294	430	432	468	498	488	450	426	340	292	498
1988:	230	276	348	402	452	484	470	465	450	404	350	280	484
1989:	213	290	371	380	448	470	463	472	460	406	300	278	472
1990:	235	254	320	426	462	462	474	461	462	418	346	301	474
Min:	213	239	288	354	421	443	444	428	425	390	272	244	452
Avg:	246	275	331	392	439	459	469	467	447	406	324	277	477
Max:	280	312	371	430	462	484	498	490	462	426	350	301	498

TABLE 29. Qaisumah (OEPA): Minimum and Maximum Temperature of Every Day of 1987 (Celsius*10)

Month:	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Day:																								
01:	14	144	140	302	180	284	128	249	250	430	246	404	289	455	320*455		193	423	242	415	170	296	109	238
02:	59	163	132	286	154	294	140	280	226	390	260	420	280	461	313*453		261	420	250	410	178	330	95	238
03:	40	190	112	299	150	194	162	344	225	410	270	421	270	433	321*482		262	428	240	426	140	268	129	244
04:	50	192	110	222	102	212	150	256	250	421	265	428	290	430	320*462		270	438	250	398	120	230	147	252
05:	70	211	80	205	110	220	127	247	262	422	260	390	290	443	320*480		272	440	230	410	120	275	150	194
06:	112	234	75	216	128	250	113	242	250	380	230	390	270	440	343*480		272	423	250	412	174	336	108	209
07:	37	170	90	250	110	250	140	266	220	378	250	408	280	453	370*488		265	422	280	392	150	270	79	184
08:	45	172	105	282	140	281	135	267	215	396	248	420	282	470	345*470		264	425	229	360	120	230	66	172
09:	70	194	118	215	142	260	154	280	250	430	260	423	299	448	304*459		272	430	180	316	109	229	84	210
10:	85	252	90	193	116	278	144	310	290	411	260	412	282	438	290	453	262	433	160	313	106	230	63	192
11:	50	180	60	188	140	270	162	331	274	395	241	399	285	453	318*470		272	442	200	330	100	232	90	218
12:	20	160	38	190	102	238	165	312	270	380	240	400	295*470		312*474		274	429	205	354	90	241	90	275
13:	10	163	38	208	130	262	196	351	251	394	260	420	290	455	310*470		268	411	223	328	130	310	130	232
14:	32	161	79	226	104	164	210	398	260	414	278	430	290	448	306*470		250	393	221	338	160	340	95	200
15:	18	182	110	282	90	256	246	393	255	428	261	444	282	453	325*473		245	398	225	360	135	283	81	215
16:	40	200	130	312	178	272	250	366	280	398	290	445	293	450	315*465		236	403	230	331	120	263	86	210
17:	35	209	140	250	134	240	248	379	268	413	280	430	279	452	292	452	245	416	220	351	112	273	94	263
18:	32	211	119	239	149	286	232	402	272	406	285	402	278	458	308*459		240	429	243	340	110	266	106	261
19:	38	226	99	240	150	256	190	272	270	396	260	411	290	460	290	412	242	422	236	368	108	272	121	292
20:	50	240	86	240	118	211	152	260	265	392	270	420	292	460	260	410	240	398	208	320	128	295	110	212
21:	65	249	85	214	110	154	148	278	263	430	255	422	282*475		250	433	220	399	194	301	135	287	90	222
22:	52	265	80	209	80	212	150	293	269	412	240	390	310*483		262	442	250	416	190	254	150	304	116	240
23:	108	280	70	230	70	216	204	353	248	406	246	412	300*480		272	420	252	420	219	334	144	303	101	255
24:	80	210	105	260	78	238	222	408	270	419	260	420	312*495		260	395	240	412	210	360	135	290	80	219
25:	99	242	125	312	126	290	230	369	300	392	245	432	313*498		250	392	272	450	190	326	134	261	68	192
26:	99	230	135	250	110	193	206	312	276	416	250	440	302*484		245	393	275	446	170	296	113	238	100	230
27:	80	190	134	259	100	219	190	298	296	374	281	465	290*478		240	383	270	430	150	258	101	249	107	195
28:	45	170	116	282	100	219	180	316	269	396	290	460	302*495		231	379	240	390	139	270	118	271	60	151
29:	39	186	...	...	100	153	210	368	294	429	295	*468	290	449	230	398	240	392	168	308	98	242	18	132
30:	72	245	...	...	90	184	222	430	274	432	292	460	297	443	230	402	230	396	185	282	94	220	4	150
31:	110	230	...	...	99	217	...	...	270	392	...	...	312	440	248	413	...	...	180	285	...	...	20	133

*: Daily Mean Temperature 100F or greater [(Min + Max)/2 > 37.7C]

TABLE 30. Extreme Temperatures (°C) by Month from Available Sources for Qaisumah

Type of Extreme	Month	1 Billions 1963-1969	2 ISMCS 1973-1989	3 Current 1981-1990	Most Extreme Value
Maximum					
	JAN		27.8	28.0	28.0
	FEB		31.1	31.2	31.2
	MAR		37.8	37.1	37.8
	APR	42.2	42.8	43.0	43.0
	MAY	46.1	45.0	46.2	46.2
	JUN	47.8	47.8	48.4	48.4
	JUL	48.9	48.3	49.8	49.8
	AUG	47.8	47.8	49.0	49.0
	SEP	45.0	46.1	46.2	46.2
	OCT	46.1	42.2	42.6	46.1
	NOV		36.1	35.0	36.1
	DEC		30.0	30.1	30.1
	ANN	48.9	48.3	49.8	49.8
Minimum					
	JAN		-2.2	-2.8	-2.8
	FEB		-1.1	-2.0	-2.0
	MAR		0.0	0.0	0.0
	APR		8.9	8.0	8.0
	MAY		16.1	14.4	14.4
	JUN		20.0	21.0	20.0
	JUL		(18.9)*	23.0	23.0
	AUG		(17.2)*	21.8	21.8
	SEP		(12.8)*	18.0	18.0
	OCT		7.8	7.0	7.0
	NOV		2.2	1.5	1.5
	DEC		0.0	-1.0	-1.0
	ANN		-2.2	-2.8	-2.8

[1] Billions: U.S. Army Missile Command Technical Report 72-13 (see Billions, 1972)
[2] ISMCS: International Station Meteorological Climate Summary (Compact Disc)
[3] Current: The data set analyzed in this report
* Dubious value (see explanation in text)

TABLE 31. Thirteen Temperature Cycles for Qaisumah (OEPA): (a) Hourly Temperatures (Celsius*10), (b) Relative Frequency of Occurrence of Each Cycle

Cycle:	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	MIL-STD-810E
	<—— Year ——>									<— Summer (JJA) —>				
LST														
0000:	56	83	120	160	200	245	293	327	362	275	302	330	362	370
0100:	52	77	113	153	192	237	284	318	354	268	293	321	354	350
0200:	51	74	109	148	186	231	277	310	346	262	284	313	346	340
0300:	52	73	105	143	181	226	269	301	336	255	275	303	336	340
0400:	52	71	101	138	175	219	259	291	326	247	265	293	326	330
0500:	49	66	95	132	168	213	252	283	318	241	258	285	318	330
0600:	44	61	91	128	165	211	252	284	321	242	260	287	321	320
0700:	42	60	92	131	171	219	265	299	337	255	276	302	337	330
0800:	47	68	103	144	188	239	290	326	364	279	303	329	364	350
0900:	58	85	121	165	212	267	322	359	396	306	334	362	396	380
1000:	71	104	143	188	238	294	350	389	423	330	360	391	423	410
1100:	83	122	163	209	259	315	370	409	442	346	377	411	442	430
1200:	91	134	177	224	273	328	382	421	454	355	387	422	454	440
1300:	96	142	187	234	283	337	389	428	463	361	393	429	463	470
1400:	101	148	194	241	290	343	395	434	470	367	399	435	470	480
1500:	104	152	198	245	295	348	400	440	475	372	405	440	475	480
1600:	105	151	196	244	293	347	401	440	474	374	407	442	474	490
1700:	100	144	189	236	284	338	394	434	466	371	402	436	466	480
1800:	91	133	176	222	269	322	380	421	452	361	390	424	452	480
1900:	82	120	162	206	253	304	363	403	436	347	375	407	436	460
2000:	76	110	149	193	238	288	346	385	420	332	358	389	420	420
2100:	72	102	141	183	227	275	330	367	404	316	342	371	404	410
2200:	68	97	134	175	218	265	316	352	388	300	327	355	388	390
2300:	63	90	127	168	209	254	304	339	374	286	313	341	374	380
Relative Frequency (%)														
Year :	1.5	9.9	14.2	11.9	11.0	10.8	23.9	16.2	0.5	---	---	---	---	
Summer:	---	---	---	---	---	---	---	---	---	0.8	43.9	53.4	2.0	

TABLE 32. Thirteen Temperature Cycles for Qaisumah (OEPA): Mean Temperature and Fourier Coefficients (Celsius)

TMEAN	A1	A2	A3	A4	B1	B2	B3	B4
Q01: 7.1	-1.5288	0.2910	-0.1859	-0.0458	-2.3462	0.6739	-0.0014	-0.3248
Q02: 10.3	-2.3499	0.5812	-0.2120	-0.0167	-3.4908	0.9444	0.0933	-0.3175
Q03: 14.1	-2.7133	0.7636	-0.1398	-0.0125	-4.1102	1.0199	0.1516	-0.2815
Q04: 18.4	-3.0764	0.8527	-0.1197	-0.0167	-4.4723	1.0105	0.2051	-0.2742
Q05: 22.8	-3.5821	0.9627	-0.0912	-0.0833	-4.8737	0.9172	0.3390	-0.3031
Q06: 27.8	-4.0908	0.9885	-0.0864	-0.1167	-5.1025	0.7919	0.4764	-0.3320
Q07: 32.8	-4.3919	1.0465	-0.0329	-0.1708	-5.6797	0.4343	0.7192	-0.2670
Q08: 36.5	-4.6393	1.0860	-0.0471	-0.1708	-6.0166	0.3554	0.8222	-0.2382
Q09: 40.0	-4.6033	1.0876	0.0122	-0.2708	-5.8810	0.2871	0.7123	-0.1516
Q10: 31.0	-3.9147	0.6892	-0.0918	-0.1875	-5.1993	0.1353	0.7198	-0.1804
Q11: 33.7	-4.2855	0.9388	0.0348	-0.2125	-5.6881	0.1028	0.8291	-0.2093
Q12: 36.7	-4.5671	1.0465	-0.0471	-0.1708	-6.0111	0.2644	0.8174	-0.2093
Q13: 40.0	-4.6033	1.0876	0.0122	-0.2708	-5.8810	0.2871	0.7123	-0.1516

TABLE 33. Summary of Ten-Year Temperature Statistics From Riyadh, Dhahran and Qaisumah (Celsius*10)

Month :	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RIYADH (OERY) , Jan 1981 -- Dec 1990:													
Record Maximum :	310	330	370	408	450	462	480	468	440	410	348	300	480
Average Monthly Max:	281	295	346	385	431	446	458	455	433	394	330	287	461(*)
Average Daily Max :	206	225	271	326	392	419	436	428	404	348	279	218	329
Mean :	144	163	208	261	325	348	365	357	330	276	213	157	262
Average Daily Min :	85	101	146	195	252	269	286	282	253	204	150	99	194
Average Monthly Min:	35	43	80	140	201	238	258	249	215	160	105	42	25(*)
Record Minimum :	-5	0	49	110	180	210	240	227	161	130	70	10	-5
DHAHRAN (OEDR) , Jan 1981 -- Dec 1990:													
Record Maximum :	280	298	370	430	480	470	480	470	460	430	368	302	480
Average Monthly Max:	245	268	331	389	440	448	463	452	433	404	335	279	467(*)
Average Daily Max :	200	214	253	315	379	405	426	414	395	347	282	222	322
Mean :	149	162	201	255	315	342	357	348	321	280	225	170	261
Average Daily Min :	96	109	148	195	246	273	287	284	253	217	170	119	200
Average Monthly Min:	48	58	91	136	201	232	257	248	215	173	125	66	44(*)
Record Minimum :	18	32	64	100	174	210	245	228	190	145	90	50	18
QAISUMAH (OEPA), Jan 1981 -- Dec 1990:													
Record Maximum :	280	312	371	430	462	484	498	490	462	426	350	301	498
Average Monthly Max:	246	275	331	392	439	459	469	467	447	406	324	277	477(*)
Average Daily Max :	175	200	247	316	386	418	442	433	412	347	257	197	320
Mean :	113	135	182	247	314	342	364	357	328	268	188	132	248
Average Daily Min :	57	72	118	176	236	255	276	272	245	195	127	75	176
Average Monthly Min:	9	20	58	110	184	223	245	239	198	135	72	12	-3(*)
Record Minimum :	-28	-20	0	80	144	210	230	218	180	70	15	-10	-28

(*) Average annual extreme

REFERENCES

AR 70-38, *Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions*, 1 August 1979.

Billions, N. S., *Frequencies and Durations of Surface Temperatures in Hot-Dry Climatic Category Areas (Cat. 4, AR 70-38)*, TR-RR-72-13, U.S. Army Missile Command, Redstone Arsenal, AL, December 1972.

Blake, D. W., T. N. Krishnamurti, S. V. Low-Nam, and J. S. Fein, "Heat Low Over the Saudi Arabian Desert During May 1979 (Summer MONEX), "*Monthly Weather Review*, Vol. 111, No. 9, pp. 1759-1775, September 1983.

Dickenson, M. L., Project Director, *International Station Meteorological Climate Summary (Compact Disc)*, joint publication of Naval Oceanography Command Detachment (LCDR M. L. Dickenson's organization), U.S. Air Force Environmental Technical Applications Center Operating Location A (USAFETAC OL-A), and the National Climatic Data Center (NCDC), Asheville, NC, October 1990.

Dodd, A. V., *Areal and Temporal Occurrence of High Dew Points and Associated Temperatures*, U.S. Army Natick Laboratories Technical Report 70-4-ES, Natick, MA, August 1969.

Encyclopedia Americana International Edition, Vol. 23: Pumps to Russell. Grolier Inc., Danbury, CT, 1987.

Environmental Technical Applications Center, *Air Weather Service Climatic Brief for Dhahran*, USAFETAC, Scott Air Force Base, IL, June 1988.

Environmental Technical Applications Center, *Air Weather Service Climatic Brief for Riyadh*, USAFETAC, Scott Air Force Base, IL, July 1985.

Environmental Technical Applications Center, *Limited Surface Observations Climatic Summary for Dhahran, Saudi Arabia*, USAFETAC/DS-85/013, Scott Air Force Base, IL, May 1985.

Environmental Technical Applications Center, *Operational Climatic Data Summary for Riyadh, Saudi Arabia*, USAFETAC/ECR, Scott Air Force Base, IL, June 1984.

Environmental Technical Applications Center, *Revised Uniform Summary of Surface Weather Observations for Dhahran, Saudi Arabia*, USAFETAC/DS-83/050, Scott Air Force Base, IL, December 1983.

Griffiths, J. F., *Applied Climatology*, Oxford University Press, London, 1966.

Hastenrath, S., A. Hafez, and E. B. Kaczmarczyk, "A Contribution to the Dynamic Climatology of Arabia," *Archiv für Meteorologie, Geophysik, und Bioklimatologie, Ser. B*, Vol. 27, pp. 105-120, 1979.

Landsberg, H. E., H. Lippmann, Kh. Paffen, and C. Troll, *World Maps of Climatology, Second Edition,* Springer-Verlag, New York, NY, 1965.

Meteorological Office of the Air Ministry of Great Britain, *Tables of Temperature, Relative Humidity, and Precipitation for the World, Part V, Asia,* Publication M. O. 617e, Her Majesty's Stationery Office, London, 1958.

Meteorological Office of Great Britain, *Tables of Temperature, Relative Humidity, Precipitation and Sunshine for the World, Part I, North America and Greenland (Including Hawaii and Bermuda),* Publication M. O. 856a, Her Majesty's Stationery Office, London, 1980.

Meteorological Office of Great Britain, *Tables of Temperature, Relative Humidity, Precipitation and Sunshine for the World, Part IV, Africa, the Atlantic Ocean South of 35°N and the Indian Ocean,* Publication M. O. 856d, Her Majesty's Stationery Office, London, 1983.

MIL-STD-810E, *Environmental Test Methods and Engineering Guidelines,* 14 July 1989.

Pedgley, D. E., "Winter and Spring Weather at Riyadh, Saudi Arabia," *Meteorological Magazine,* Vol. 103, pp. 225-236, 1974.

Rudloff, W., *World-Climates,* Wissenschaftliche Verlagsgesellschaft, Stuttgart, Germany, 1981.

Smith, E. A., "The Structure of the Arabian Heat Low, Part I: Surface Energy Budget," *Monthly Weather Review,* Vol. 114, No. 6, pp. 1067-1083, June 1986a.

Smith, E. A., "The Structure of the Arabian Heat Low, Part II: Bulk Tropospheric Heat Budget and Implications," *Monthly Weather Review,* Vol. 114, No. 6, pp. 1084-1102, June 1986b.

Soltani, G., *The Climate of Iraq and the Arabian Peninsula,* Air Weather Service Forecaster Memo AWS/FM-90/004, September 1990.

Takahashi, K., and H. Arakawa, *Climates of Southern and Western Asia, World Survey of Climatology, Vol. 9,* H. E. Landsberg, Editor-in-Chief, Elsevier, Amsterdam, see pp. 183-255, 1981.

U.S. Naval Weather Service, *World-Wide Airfield Summaries,Vol. II, Part 2, Middle East,* October 1967.

Vojtesak, M. J., K. P. Martin, G. Myles, and M. T. Gilford, *SWANEA (Southwest Asia-Northeast Africa), A Climatological Study, Vol. II--The Middle East Peninsula,* USAFETAC/TN-91/002, Scott Air Force Base, IL, February 1991.

APPENDIX

APPENDIX

Figure A1 shows actual daily minimum and maximum Riyadh temperatures from the period 1 July 1990 to 30 June 1991 plotted as vertical lines. The climatological background is represented by smooth curves. The middle three curves are the smoothed five-day averages of daily low, daily mean, and daily high temperatures from Table 3. The two outside curves are envelopes of five-day extremes during the ten-year period. The wavy center curve is a plot of the daily mean computed as simple average of the 1990/91 minimum and maximum, but smoothed by the low-pass filter mentioned earlier in the text. The graph vividly shows the larger interdiurnal changes during winter caused by synoptic-scale weather systems that moved across Saudi Arabia between December and May and led to invasions of colder air in intervals of about 14 days.

While cooler-than-normal May 1991 temperatures at Dhahran and Bahrain have been mentioned in connection with the then still burning oil-well fires in Kuwait, the graph shows that May 1991 was also cooler than average at Riyadh. This would indicate that the below-normal May temperatures were a widespread phenomenon which may have been caused by large-scale meteorological processes.

During the winter of 1991/92 unusually harsh winter conditions occurred in the Middle East and Southwest Asia. Reports of heavy snow fall and low temperatures were received from eastern Turkey, Israel and Jordan. At the Saudi stations discussed here, several low temperature records were broken: Qaisumah experienced a December record low of –3 °C on the 19th. Then, on 5 January 1992, a low temperature of –4.0 °C was reported by Qaisumah, exceeding the previous extreme of –2.8 °C (Table 30). On the next day (6 January 1992), Riyadh International (OERY) recorded –1.0 °C, slightly exceeding the 1981–1990 record low of –0.5 °C. Riyadh also had the coldest month of January, at least since 1979.

As a continuation of the plot of Riyadh temperatures depicted in Figure A1, Figure A2 has been constructed directly from the teletype reports received between 1 July 1991 and 13 March 1992. The graph of the smoothed daily mean temperatures reveals that cold spells tended to occur in intervals of approximately 17 to 20 days, starting in mid–December. During January, temperatures remained below average, even between these cold spells.

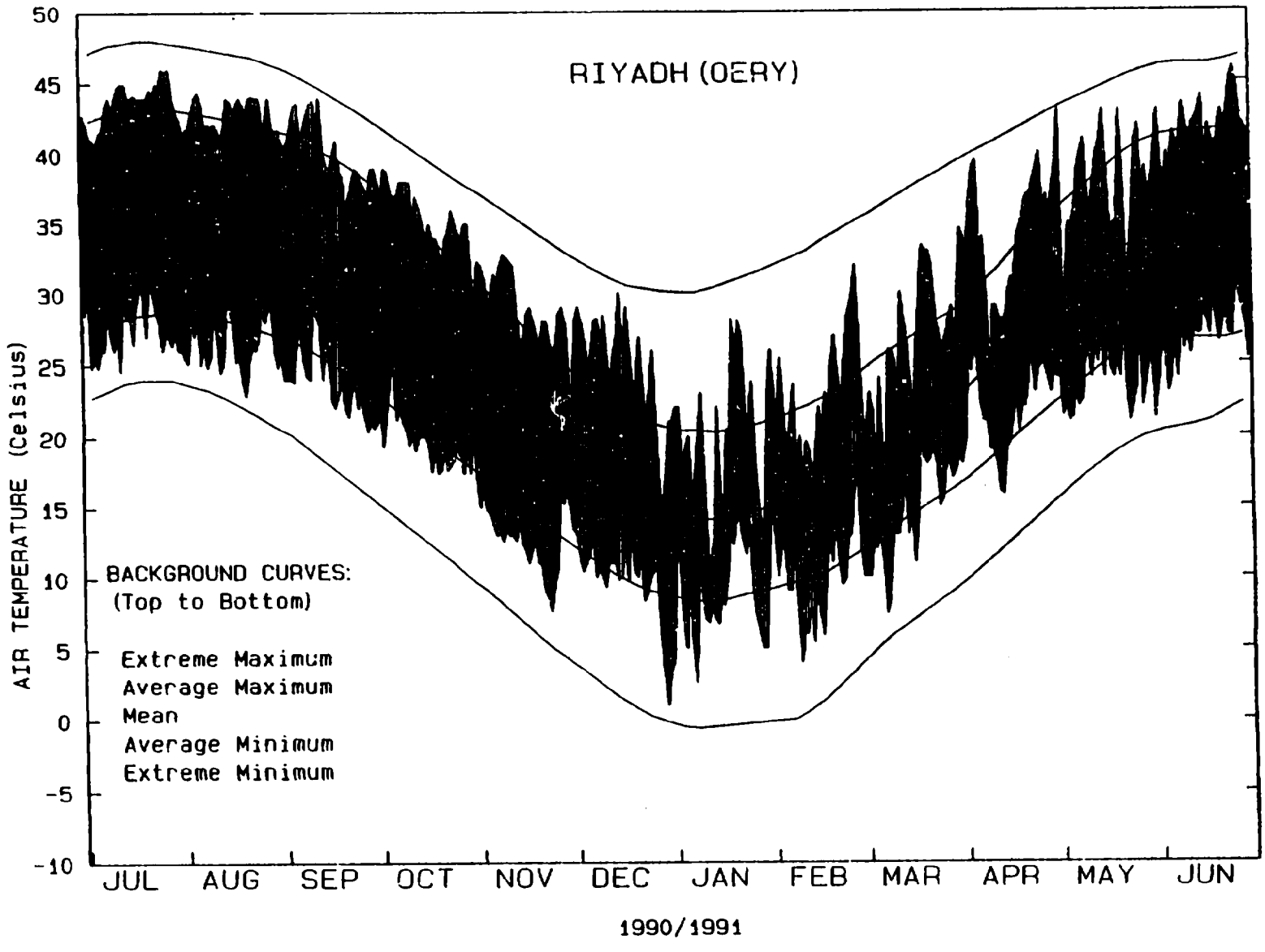


Figure A1. Riyadh daily low and high temperatures 1 Jul 90 to 30 Jun 91 and climatological background

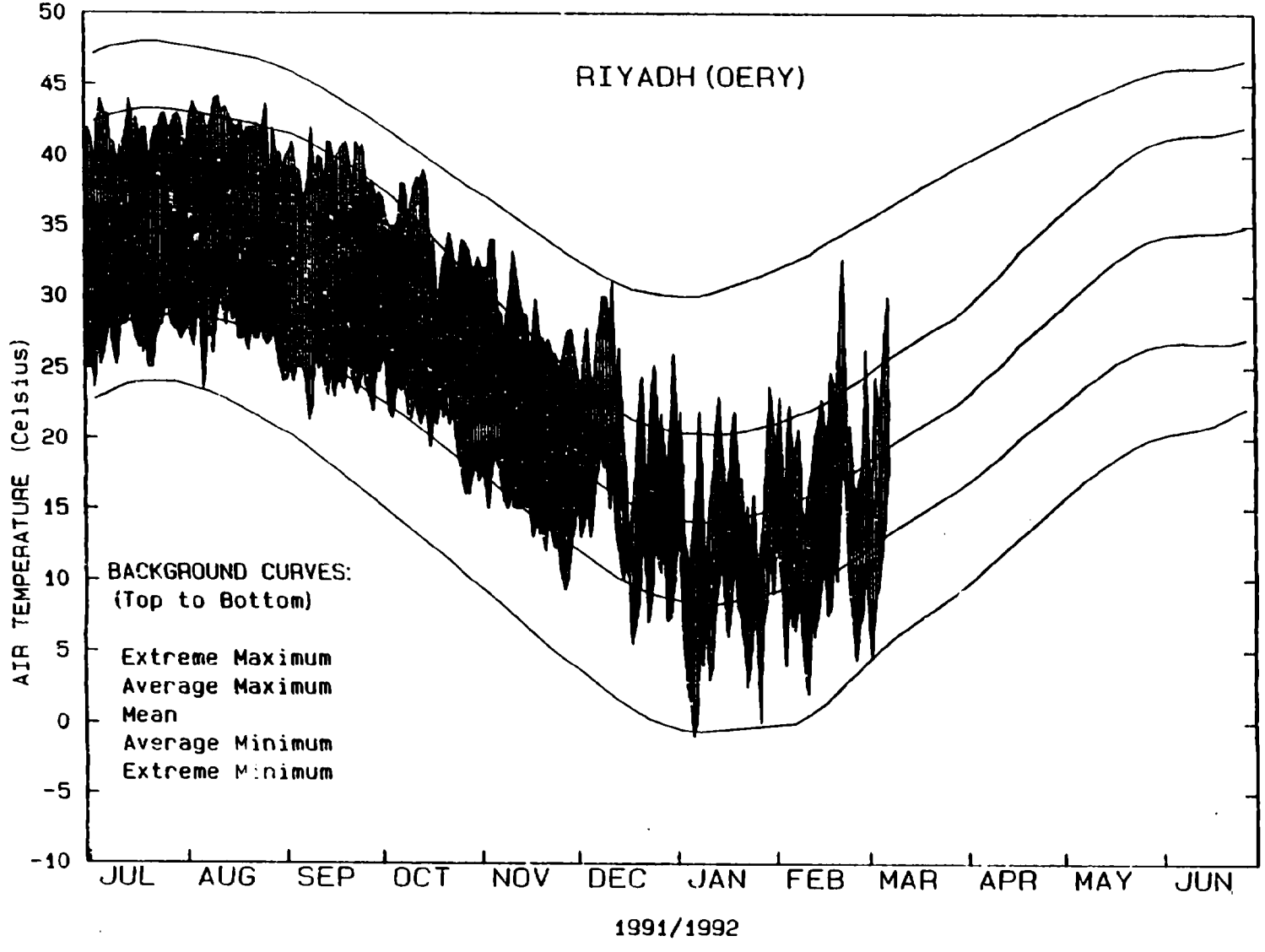


Figure A2. **Riyadh daily low and high temperatures 1 Jul 91 to 13 March 92 and climatological background.**

DISTRIBUTION

	Copies
U. S. Army Materiel System Analysis Activity ATTN: AMXSY-MP/Herbert Cohen Aberdeen Proving Ground, MD 21005	1
Director U. S. Army Research Office ATTN: SLCRO-PH P. O. Box 12211 Research Triangle Park, NC 27709-2211	1
Headquarters Department of the Army ATTN: DAMA-ARR Washington, DC 20310-0632	1
Headquarters, Department of the Army ATTN: DDR&E/R&AT/E&LS The Pentagon Washington, D. C. 20310-0632	1
HQDA/OACSI ATTN: DAMI-POI/Mr. Lee Page Washington, DC 20310-1067	1
U.S. Army CETEC/GL-AE ATTN: Mr. Paul Krause Ft. Belvoir, VA 22060	1
U.S. Army Laboratory Command Atmospheric Sciences Laboratory ATTN: SLCAS-AM-A, Mr. Abel Blanco White Sands Missile Range, NM 88002	1
USAFETAC/OL-A ATTN: Mr. Jon Whiteside Federal Building Asheville, NC 28801	1
USAFETAC/ECE ATTN: Ms. Snelling Scott Air Force Base, IL 62225-5438	1
Air Weather Service Technical Library FL 4414 Scott Air Force Base, IL 62225-5438	1

	Copies
National Oceanic and Atmospheric Administration Library - EOC4WSC4 ATTN: ACQ Washington, DC 20230	1
Director Atmospheric Science Program National Science Foundation Washington, DC 20550	1
GL Library ATTN: SULLR, Stop 29 Hanscom AFB, MA 01731-5000	1
ITT Research Institute ATTN: GACIAC 10 W. 35th Street Chicago, IL 60616	1
NASA/Marshall Space Flight Center ATTN: Mail Code ED43 Huntsville, AL 35812	1
Commander U. S. Army Strategic Defense Command ATTN: DASD-H-V P. O. Box 1500 Huntsville, AL 35807-3801	1
AMSMI-RD	1
AMSMI-RD-AC, Dr. B. W. Fowler	1
AMSMI-RD-AS, Mr. Guilford J. Hutcheson	1
AMSMI-RD-CS-R	15
AMSMI-RD-CS-T	1
AMSMI-RD-PR-S, Mr. J. M. Lyon	1
Mr. M. S. Counter	1
AMSMI-RD-SE-EA, Dr. J. H. Donnelly	1
AMSMI-RD-SI, Mr. W. D. Hagler	1
AMSMI-RD-SS, Mr. J. D. Coombs	1
AMSMI-RD-ST-CM, Mr. L. W. Howard	1
AMSMI-RD-TE	1
AMSMI-RD-TI	1
AMSMI-RD-WS, Dr. Bennett	1
S. Troglen	1

DISTRIBUTION (cont'd)

	Copies
AMSMI-RD-WS-CM, Dr. Stewart	10
Mr. Dudel	10
Mr. Levitt	10
AMSMI-GC-IP, Mr. Fred Bush	1
SFAE-FS-HD-E-M, Mr. D. G. Boyd	1
SFAE-FS-ML-MG, Mr. B. L. Crosswhite	1
SFAE-FS-ML-MS, LTC Wolfe	1